SUPREME COURT OF THE UNITED STATES

October Term, 1938

No. 515

THE UNITED STATES OF AMERICA, PETITIONER

vs.

DUBILIER CONDENSER CORPORATION

No. 516

THE UNITED STATES OF AMERICA, PETITIONER

vs.

DUBILIER CONDENSER CORPORATION

No. 518

THE UNITED STATES OF AMERICA, PETITIONER

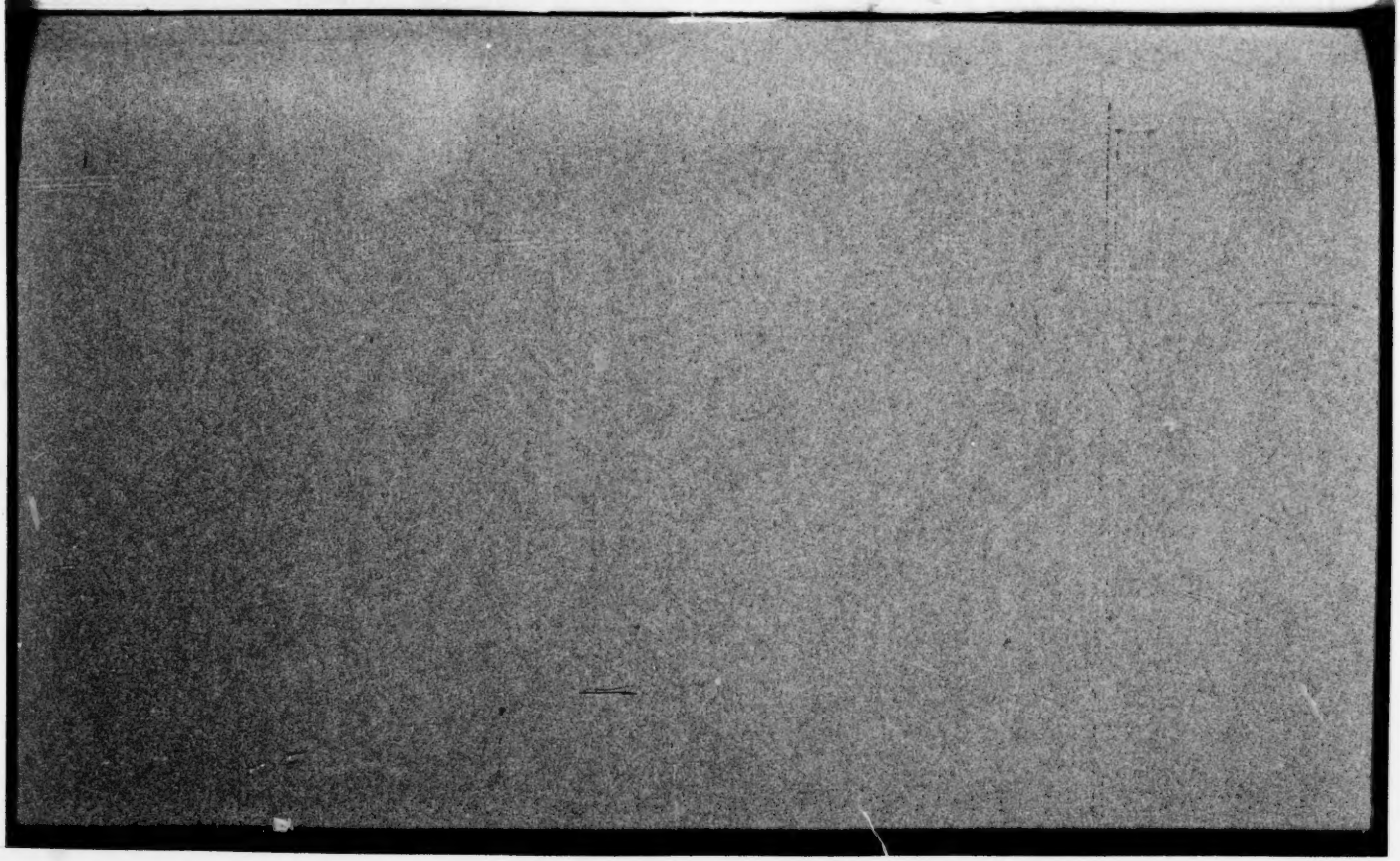
vs.

DUBILIER CONDENSER CORPORATION

ON WRITS OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE THIRD CIRCUIT.

PETITIONS FOR CERTIORARI FILED AUGUST 24, 1938.
CERTIORARI GRANTED OCTOBER 17, 1938.

(37013, 37014, 37015)



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In the District Court of the United States for the District of Delaware

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Nos. 788, 789, 790, IN EQUITY

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

FOR PLAINTIFF:

CHARLES B. RUGG, *Assistant Attorney General.*
ALEXANDER HOLTZOFF, *Special Assistant to the Attorney General.*
FRANK J. KEATING, *Attorney.*
ARTHUR B. YORK, *Special Assistant to the Attorney General.*
LEONARD E. WALES, *United States Attorney.*

FOR DEFENDANT:

JAMES H. HUGHES, Jr., Esq.
E. ENNALLS BERL, Esq.
JOHN B. BRADY, Esq.

UNITED STATES OF AMERICA,
District of Delaware, ss:

Be it remembered, that at a District Court of the United States for the District of Delaware, begun and held at the United States Court House and Post Office Building, in the city of Wilmington, in the said District of Delaware, among other, the following proceedings were had, to wit:

In the District Court of the United States for the District of Delaware

No. 788 In Equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Docket entries

April 22, 1930. Bill of complaint filed; same day subpœna issued returnable May 12, 1930.

April 24, 1930. Marshal returns on subpœna, "Served," &c.; same day writ filed.

May 3, 1930. Defendant appears by James H. Hughes, jr., its solicitor; same day præcipe filed.

May 5, 1930. Stipulation filed; same day order extending time to file answer until June 2, 1930; same day order filed.

May 26, 1930. Answer filed.

Sept. 10, 1930. Order appointing Wm. F. Smart as stenographer, &c.; same day order filed.

Sept. 11, 1930. Petition of defendant filed; same day requests to Secretary of War, Secretary of Navy, Secretary of Commerce, and the Attorney General to furnish copies, &c.; same day request filed.

Sept. 29, 1930. Plaintiff's notice of taking depositions, filed.

Oct. 7, 8, 9, 10, 1930. Trial before the court.

Oct. 10, 1930. Deposition of John P. Buckley on behalf of plaintiff filed.

Oct. 10, 1930. Record of proceedings at trial filed.

Nov. 24, 1930. Hearing on pleadings and proofs.

Mar. 16, 1931. Stipulation for correction of record of trial, filed.

April 27, 1931. Opinion of court filed.

May 5, 1931. Decree dismissing bill of complaint; same day decree filed.

June 15, 1931. Petition of plaintiff for appeal, with assignments of error, filed; same day order allowing appeal; same day order filed.

June 15, 1931. Citation issued.

June 16, 1931. Citation with acceptance of service by solicitor for defendant-appellee endorsed thereon, filed.

Sept. 21, 1931. Order approving stipulation as to condensed record; same day order, stipulation and condensed record filed.

Sept. 21, 1931. Order approving stipulation as to transcript of record; same day order and stipulation filed.

In the District Court of the United States for the District of Delaware

No. 789 In Equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Docket entries

April 22, 1930. Bill of complaint filed; same day subpœna issued, returnable May 12, 1930.

April 24, 1930. Marshal returns on subpœna, "Served," &c.; same day writ filed.

May 3, 1930. Defendant appears by James H. Hughes, jr., Esq., its solicitor; same day præcipe filed.

May 5, 1930. Stipulation filed; same day order extending time for filing answer until June 2, 1930; same day order filed.

May 26, 1930. Answer filed.

Sept. 10, 1930. Order appointing Wm. F. Smart as stenographer, &c.; same day order filed.

Sept. 11, 1930. Petition of defendant filed; same day requests to Secretary of War, Secretary of the Navy, Secretary of Commerce, and the Attorney General to furnish copies, &c.; same day requests filed. (Filed in No. 788.)

Sept. 29, 1930. Plaintiff's notice of taking depositions, filed. (Filed in No. 788.)

Oct. 7, 8, 9, 10, 1930. Trial before the court.

Oct. 10, 1930. Deposition of John P. Buckley on behalf of plaintiff filed. (Filed in No. 788.)

Oct. 10, 1930. Record of proceedings at trial, filed.

Nov. 24, 1930. Hearing on pleadings and proofs.

Mar. 16, 1931. Stipulation for correction of record of trial filed. (Filed in No. 788.)

April 27, 1931. Opinion of court filed. (Filed in No. 788.)

May 5, 1931. Decree dismissing bill of complaint; same day decree filed.

June 15, 1931. Petition of plaintiff for appeal, with assignments of error, filed; same day order allowing appeal; same day order filed.

June 15, 1931. Citation issued.

June 16, 1931. Citation with acceptance of service by solicitor for defendant-appellee endorsed thereon, filed.

Sept. 21, 1931. Order approving stipulation as to condensed record; same day order, stipulation and condensed record filed.

Sept. 21, 1931. Order approving stipulation as to transcript of record; same day order and stipulation filed.

In the District Court of the United States for the District of Delaware

No. 790 In Equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Docket entries

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April 24, 1930. Marshal returns on subpœna, "Served", &c.; same day writ filed.

May 3, 1930. Defendant appears by James H. Hughes, jr., Esq., its solicitor; same day præcipe filed.

May 5, 1930. Stipulation filed; same day order extending time to file answer until June 2, 1930; same day order filed.

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May 5, 1931. Decree dismissing bill of complaint; same day decree filed.

June 15, 1931. Petition of plaintiff for appeal, with assignments of error, filed; same day order allowing appeal; same day order filed.

June 15, 1931. Citation issued.

June 16, 1931. Citation, with acceptance of service by solicitor for defendant-appellee endorsed theron, filed.

Sept. 21, 1931. Order approving stipulation as to condensed record; same day order, stipulation and condensed record filed.

Sept. 21, 1931. Order approving stipulation as to transcript of record; same day order and stipulation filed.

Bill of complaint

(Filed April 22, 1930)

In the District Court of the United States for the District of Delaware

In Equity No. 788

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

To the Honorable Judge of the District Court of the United States for the District of Delaware:

The United States of America brings this its bill of complaint against Dubilier Condenser Corporation, and for cause of action alleges:

I. This is a suit in equity brought by the United States of America as plaintiff.

II. As the plaintiff is informed and believes, the defendant Dubilier Condenser Corporation is a corporation organized under the laws of the State of Delaware and an inhabitant of the district of Delaware.

III. At all times hereinafter mentioned, the Bureau of Standards was and now is a subdivision of the Department of Commerce. The functions of said Bureau of Standards comprise the custody of standards; the comparison of the standards used with the standards adopted or recognized by the Government; the construction, the testing, and the calibration of standards; and the conduct of scientific investigation, experimentation, studies, and research in general.

IV. At all times hereinafter mentioned the Bureau of Standards maintained and now maintains a radio section. The said radio section carries on calibration of various radio instruments and conducts scientific investigation, experiments, studies, and research in the radio field, and prepares and publishes scientific papers containing the results of its work for the purpose of disseminating knowledge to the parties interested therein and to the public generally. For the purpose of carrying on its work the said radio section maintains a radio laboratory.

V. As the plaintiff is informed and believes, one Percival D. Lowell, and one Francis W. Dunmore, are physicists and are trained in carrying on research and experimentation in various branches of physics and the science of electricity, including radio. Between February 4, 1913, and July 15, 1922, the said Lowell was employed in said radio section in the successive capacities of laboratory apprentice and associate physicist. From January 14, 1918, to date, the said Dunmore was employed in said radio section in the successive capacities of laboratory assistant and associate physicist. It was one of the duties of said Lowell and of said Dunmore to carry on investigation, research, and experimentation in such problems relating to radio and wireless as might be assigned to them by their superiors, and to report the results thereof to their said superiors, and to assist, advise, and cooperate with other employees of said radio section in the performance of tasks assigned to them.

VI. In the course of his employment as aforesaid, there was assigned to the said Lowell by his superiors in said radio section, for investigation and research, the problem of developing a radio receiving set capable of operation by alternating electric current as supplied by electric power companies for residences and other buildings, so that the use of electric batteries might be eliminated in connection with radio receiving apparatus.

VII. As the plaintiff is informed and believes, the said Lowell pursuant to the aforesaid directions and instructions given him by his superiors, proceeded to carry on studies, research, investigation, and experimentation in said problems, and the said Dunmore advised, assisted, and cooperated with said Lowell in the performance of the aforesaid work. The aforesaid work was done by said Lowell and said Dunmore at said radio laboratory of the Bureau of Standards with apparatus and materials which were the property of the plaintiff and during their usual hours of employment. The aforesaid work was done by said Lowell and said Dunmore as one of the duties of their employment as aforesaid, and the results and product of said work are the property of the plaintiff.

VIII. Some time prior to March 27, 1922, the said Lowell and the said Dunmore solved the problem assigned to them by their superiors as aforesaid and completed the said work hereinabove referred to by developing and inventing a radio receiving apparatus capable of being satisfactorily operated by alternating current received from the standard residence lighting power. The aforesaid development and invention and all rights and interests therein are the property of the United States.

IX. As the plaintiff is informed and believes, the said Percival D. Lowell and the said Francis W. Dunmore, in disregard of their duties to the plaintiff, and ignoring the rights of the plaintiff, and

without the knowledge or approval of the plaintiff, filed in the United States Patent Office on March 27, 1922, an application for letters patent on said invention. Thereafter on May 15, 1923, letters patent of the United States numbered 1455141 and covering the said invention were issued to the said Percival D. Lowell and Francis W. Dunmore on the basis of the said application.

X. The aforesaid letters patent are in equity and good conscience the property of the United States. Although the plaintiff demanded that the aforesaid letters patent be conveyed to the plaintiff, such demand has not been complied with.

XI. As the plaintiff is informed and believes, the said Lowell and the said Dunmore have unlawfully and illegally and in disregard of the plaintiff's rights purported to grant an exclusive license under the said letters patent to the defendant Dubilier Condenser Corporation.

XII. As the plaintiff is informed and believes, the defendant has at various times collected and received various sums of money from divers persons as royalties or license fees in connection with and arising out of said letters patent, which said moneys in equity and good conscience belong to the plaintiff and the said defendant holds the same in trust and for the benefit of the plaintiff.

XIII. The said Percival D. Lowell and Francis W. Dunmore are not made parties to this action because they are not within the jurisdiction of this court, in that, as the plaintiff is informed and believes, the said Lowell is an inhabitant of the Eastern District of New York and the said Dunmore is an inhabitant of the District of Columbia.

XIV. The plaintiff has no remedy at law.

Wherefore, the plaintiff prays this honorable court as follows:

1. That it be adjudged and decreed that the plaintiff is the owner of the invention hereinabove referred to, and the defendant holds its interest therein as trustee and for the benefit of the plaintiff.

2. That it be adjudged and decreed that the plaintiff is the owner of letters patent of the United States numbered 1455141 and issued on May 15, 1923, and that the defendant holds its interest therein as trustee and for the benefit of the plaintiff.

3. That the defendant be directed and compelled to assign, transfer, and convey to the plaintiff all its right, title, and interest in and to the aforesaid invention and the aforesaid letters patent.

4. That the defendant be compelled and directed to account and pay over to the plaintiff all moneys received by it in connection with or arising out of the said invention and the said letters patent.

5. That the plaintiff have such other and further relief as to the court may seem just, together with the costs of this action.

6. That this honorable court issue its writ of subpœna in due form of law and according to the course and practice of this court directed to the said defendant Dubilier Condenser Corporation, commanding it at a certain date and under a certain penalty to be therein specified to appear before this honorable court to answer all and singular the matters hereinbefore set forth and complained of and to stand by and abide and perform all of the orders and decrees of the court herein.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

(Sgd.) ALEXANDER HOLTZOFF,
Special Assistant to the Attorney General,
Of Counsel.

Bill of complaint

(Filed April 22, 1930)

In the District Court of the United States for the District of Delaware

In Equity No. 789

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

To the honorable Judge of the District Court of the United States for the District of Delaware:

The United States of America brings this, its bill of complaint against Dubilier Condenser Corporation, and for cause of action alleges:

I. This is a suit in equity brought by the United States of America as plaintiff.

II. As the plaintiff is informed and believes, the defendant Dubilier Condenser Corporation is a corporation organized under the laws of the State of Delaware and an inhabitant of the district of Delaware.

III. At all times hereinafter mentioned, the Bureau of Standards was and now is a subdivision of the Department of Commerce. The functions of said Bureau of Standards comprise the custody of standards; the comparison of the standards used with the standards adopted or recognized by the Government; the construction, the testing, and the calibration of standards; and the conduct of scientific investigation, experimentation, studies, and research in general.

IV. At all times hereinafter mentioned the Bureau of Standards maintained and now maintains a radio section. The said radio section carries on calibration of various radio instruments, and conducts scientific investigation, experiments, studies, and research in the radio field, and prepares and publishes scientific papers containing the results of its work for the purpose of disseminating knowledge to the parties interested therein and to the public generally. For the purpose of carrying on its work the said radio section maintains a radio laboratory.

V. As the plaintiff is informed and believes, one, Percival D. Lowell, and one, Francis W. Dunmore, are physicists and are trained in carrying on research and experimentation in various branches of physics and the science of electricity, including radio. Between February 4, 1913, and July 15, 1922, the said Lowell was employed in said radio section in the successive capacities of laboratory apprentice and associate physicist. From January 14, 1918, to date, the said Dunmore was employed in said radio section in the successive capacities of laboratory assistant and associate physicist. It was one of the duties of said Lowell and of said Dunmore to carry on investigation, research, and experimentation in such problems relating to radio and wireless as might be assigned to them by their superiors, and to report the results thereof to their said superiors, and to assist, advise, and cooperate with other employees of said radio section in the performance of tasks assigned to them.

VI. In the course of his employment as aforesaid, there was assigned to said Lowell by his superiors in said radio section, for investigation and research, the problem of developing an amplifier, otherwise known as a "loud speaker," capable of operation by alternating electric current as supplied by electric power companies for residences and other buildings.

VII. As the plaintiff is informed and believes, the said Lowell pursuant to the aforesaid directions and instructions given him by his superiors, proceeded to carry on studies, research, investigation, and experimentation in said problems, and the said Dunmore advised, assisted, and cooperated with said Lowell in the performance of the aforesaid work. The aforesaid work was done by said Lowell and said Dunmore at said radio laboratory of the Bureau of Standards with apparatus and materials which were the property of the plaintiff; and during their usual hours of employment. The aforesaid work was done by said Lowell and said Dunmore as one of the duties of their employment as aforesaid, and the results and product of said work are the property of the plaintiff.

VIII. Some time prior to March 21, 1922, the said Lowell and the said Dunmore solved the problem assigned to them by their superiors as aforesaid and completed the said work hereinabove referred to by developing and inventing an amplifier or "loud speaker," capable of being satisfactorily operated by alternating current received from the standard residence lighting power. The aforesaid development and invention and all rights and interests therein are the property of the United States.

IX. As the plaintiff is informed and believes, the said Percival D. Lowell and the said Francis W. Dunmore, in disregard of their duties to the plaintiff, and ignoring the rights of the plaintiff, and

without the knowledge or approval of the plaintiff, filed in the United States Patent Office on March 21, 1922, an application for letters patent on said invention. Thereafter on November 9, 1926, letters patent of the United States numbered 1606212 and covering the said invention were issued to the said Percival D. Lowell and Francis W. Dunmore on the basis of the said application.

X. The aforesaid letters patent are in equity and good conscience the property of the United States. Although the plaintiff demanded that the aforesaid letters patent be conveyed to the plaintiff, such demand has not been complied with.

XI. As the plaintiff is informed and believes, the said Lowell and the said Dunmore have unlawfully and illegally and in disregard of the plaintiff's rights purported to grant an exclusive license under the said letters patent to the defendent Dubilier Condenser Corporation.

XII. As the plaintiff is informed and believes the defendant has at various times collected and received various sums of money from divers persons as royalties or license fees in connection with and arising out of said letters patent, which said moneys in equity and good conscience belong to the plaintiff and the said defendant holds the same in trust and for the benefit of the plaintiff.

XIII. The said Percival D. Lowell and Francis W. Dunmore are not made parties to this action because they are not within the jurisdiction of this court, in that, as the plaintiff is informed and believes, the said Lowell is an inhabitant of the Eastern District of New York and the said Dunmore is an inhabitant of the District of Columbia.

XIV. The plaintiff has no remedy at law.

Wherefore, the plaintiff prays this honorable court as follows:

1. That it be adjudged and decreed that the plaintiff is the owner of the invention hereinabove referred to and the defendant holds its interest therein as trustee and for the benefit of the plaintiff.

2. That it be adjudged and decreed that the plaintiff is the owner of letters patent of the United States numbered 1606212 and issued on November 9, 1926, and that the defendant holds its interest therein as trustee and for the benefit of the plaintiff.

3. That the defendant be directed and compelled to assign, transfer, and convey to the plaintiff all its right, title, and interest in and to the aforesaid invention and the aforesaid letters patent.

4. That the defendant be compelled and directed to account and pay over to the plaintiff all moneys received by it in connection with or arising out of the said invention and the said letters patent.

5. That the plaintiff have such other and further relief as to the court may seem just, together with the costs of this action.

6. That this honorable court issue its writ of subpœna in due form of law and according to the course and practice of this court directed to the said defendant Dubilier Condenser Corporation, commanding it at a certain date and under a certain penalty to be therein specified, to appear before this honorable court to answer all and singular the matters hereinbefore set forth and complained of and to stand by and abide and perform all of the orders and decrees of the court herein.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

(Sgd.) ALEXANDER HOLTZOFF,
Special Assistant to the Attorney General,
Of Counsel.

Bill of Complaint

(Filed April 22, 1930)

In the District Court of the United States for the District of Delaware

In Equity No. 790

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

To the Honorable Judge of the District Court of the United States for the District of Delaware:

The United States of America brings this its bill of complaint against Dubilier Condenser Corporation, and for cause of action alleges:

I. This is a suit in equity brought by the United States of America as plaintiff.

II. As the plaintiff is informed and believes, the defendant Dubilier Condenser Corporation is a corporation organized under the laws of the State of Delaware and an inhabitant of the District of Delaware.

III. At all times hereinafter mentioned the Bureau of Standards was and now is a subdivision of the Department of Commerce. The functions of said Bureau of Standards comprise the custody of standards; the comparison of the standards used with the standards adopted or recognized by the Government; the construction, the testing, and the calibration of standards; and the conduct of scientific investigation, experimentation, studies, and research in general.

IV. At all times hereinafter mentioned the Bureau of Standards maintained and now maintains a radio section. The said radio section carries on calibration of various radio instruments and conducts scientific investigation, experiments, studies, and research in the radio field, and prepares and publishes scientific papers containing the results of its work for the purpose of disseminating knowledge to the parties interested therein and to the public generally. For the purpose of carrying on its work the said radio section maintains a radio laboratory.

V. As the plaintiff is informed and believes, one Francis W. Dunmore is a physicist and is trained in carrying on research and experimentation in various branches of physics and the science of electricity, including radio. From January 14, 1918, to date, the

said Dunmore was employed in said radio section in the successive capacities of laboratory assistant and associate physicist. It was one of the duties of said Dunmore to carry on investigation, research, and experimentation in such problems relating to radio and wireless as might be assigned to him by his superiors and to report the results thereof to his said superiors.

VI. In the course of his employment as aforesaid, there was assigned to said Dunmore by his superiors in said radio section, for investigation and research, the problem of developing a radio receiving system operating a relay for the local or remote control of auxiliary apparatus.

VII. As the plaintiff is informed and believes, the said Dunmore, pursuant to the aforesaid directions and instructions given him by his superiors, proceeded to carry on studies, research, investigation, and experimentation in said problem. The aforesaid work was done by said Dunmore at said radio laboratory of the Bureau of Standards with apparatus and materials which were the property of the plaintiff and during his usual hours of employment. The aforesaid work was done by said Dunmore as one of the duties of his employment as aforesaid, and the results and product of said work is the property of the plaintiff.

VIII. Some time prior to the 27th day of February, 1922, the said Dunmore solved the problem assigned to him by his superiors as aforesaid and completed the said work hereinabove referred to by developing and inventing an apparatus known as a "radio relay." The aforesaid development and invention and all rights and interests therein are the property of the United States.

IX. As the plaintiff is informed and believes, the said Dunmore, in disregard of his duties to the plaintiff and ignoring the rights of the plaintiff, and without the knowledge or approval of the plaintiff, filed in the United States Patent Office on February 27, 1922, an application for letters patent on said invention. Thereafter on July 5, 1927, letters patent of the United States numbered 1635117, and covering the said invention, were issued to said Francis W. Dunmore on the basis of the said application.

X. The aforesaid letters patent are in equity and good conscience, the property of the United States. Although the plaintiff demanded that the aforesaid letters patent be conveyed to the plaintiff, such demand has not been complied with.

XI. As the plaintiff is informed and believes, the said Dunmore has unlawfully and illegally and in disregard of the plaintiff's rights purported to grant an exclusive license under the said letters patent to the defendant Dubilier Condenser Corporation in so far as the said letters patent cover radio telephone broadcast receiving apparatus; and to Morkrum Company, a corporation

organized and existing under the laws of the State of Maine, in so far as the device covered thereby may be used with printing telegraph apparatus.

XII. As the plaintiff is informed and believes, the defendant has at various times collected and received various sums of money from divers persons as royalties or license fees in connection with and arising out of said letters patent, which said moneys in equity and good conscience belong to the plaintiff, and the said defendant holds the same in trust and for the benefit of the plaintiff.

XIII. The said Francis W. Dunmore and Morkrum Company are not made parties to this action because they are not within the jurisdiction of this court in that, as the plaintiff is informed and believes, the said Dunmore is an inhabitant of the District of Columbia and the said Morkrum Company is an inhabitant of the district of Maine.

XIV. The plaintiff has no remedy at law.

Wherefore, the plaintiff prays this honorable court as follows:

1. That it be adjudged and decreed that the plaintiff is the owner of the invention hereinabove referred to and the defendant holds its interest therein as trustee and for the benefit of the plaintiff.

2. That it be adjudged and decreed that the plaintiff is the owner of letters patent of the United States numbered 1635117, and issued on July 5, 1927, and that the defendant holds its interest therein as trustee and for the benefit of the plaintiff.

3. That the defendant be directed and compelled to assign, transfer, and convey to the plaintiff all its right, title, and interest in and to the aforesaid invention and the aforesaid letters patent.

4. That the defendant be compelled and directed to account and pay over to the plaintiff all moneys received by it in connection with or arising out of the said invention and the said letters patent.

5. That the plaintiff have such other and further relief as to the court may seem just, together with the costs of this action.

6. That this honorable court issue its writ of subpœna in due form of law and according to the course and practice of this court directed to the said defendant Dubilier Condenser Corporation, commanding it at a certain date and under a certain penalty to be therein specified, to appear before this honorable court to answer all and singular the matters hereinbefore set forth and complained of and to stand by and abide and perform all of the orders and decrees of the court herein.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

(Sgd.) ALEXANDER HOLTZOFF,
Special Assistant to the Attorney General,
Of Counsel.

Answer

(Filed May 26, 1930)

In the District Court of the United States for the District of Delaware

Equity No. 788

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Now comes the defendant above named and answers plaintiff's bill of complaint as follows:

I. Defendant admits the allegations contained in Paragraph I of the bill of complaint.

II. Defendant admits the allegations contained in Paragraph II of the bill of complaint.

III. Defendant denies each and every of the allegations contained in Paragraph III of the bill of complaint.

IV. Answering Paragraph IV of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

V. Answering Paragraph V of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

VI. Answering Paragraph VI of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

VII. Answering Paragraph VII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters alleged in the first two sentences therein, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said

two sentences are deemed material. The defendant denies each and every of the other allegations contained in said paragraph numbered VII.

VIII. Answering Paragraph VIII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters alleged in the first sentence therein, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said sentence are deemed material. The defendant denies each and every of the other allegations contained in said paragraph numbered VIII.

IX. As to the matters alleged in Paragraph IX of the bill of complaint, defendant admits that on March 27, 1922, one Percival D. Lowell and Francis W. Dunmore filed application for United States letters patent and secured thereon on May 15, 1923, letters patent of the United States numbered 1455141. As to all other matters in Paragraph IX the defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

X. Defendant denies each and every of the allegations contained in Paragraph X of the bill of complaint, and defendant further alleges that no officer or agency of the United States Government was or is authorized to acquire the invention of the Letters Patent 1455141 on behalf of the Government.

XI. Answering Paragraph XI of the bill of complaint, defendant admits that a license was granted to it under Letters Patent 1455141, and defendant denies each and every of the other allegations contained in said Paragraph XI.

XII. Answering Paragraph XII of the bill of complaint, defendant admits that it has at various times collected and received various sums of money from divers persons as royalties or license fees in connection with and arising out of letters patent numbered 1455141, but defendant denies that any of the said money belongs to plaintiff and denies that it holds the said money or any other property for the benefit of the plaintiff.

XIII. Answering Paragraph XIII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

XIV. Answering Paragraph XIV of the plaintiff's bill of complaint, defendant denies the allegations contained therein.

Wherefore, having duly answered the bill of complaint, this defendant denies that the plaintiff is entitled to the relief demanded, or to any part of the same, and prays that the bill of complaint be dismissed with costs.

DUBILIER CONDENSER CORPORATION,
By (Sgd.) ROY E. SWENEY,
Secretary-Treasurer.
(Sgd.) JAMES H. HUGHES, Jr.,
Solicitor for Defendant.

STATE OF NEW YORK,
County of Bronx, ss:

Roy E. Sweney, being duly sworn, deposes and says that he is secretary-treasurer of the Dubilier Condenser Corporation, the defendant in this suit, that he has read the foregoing answer to the bill of complaint in this suit and knows the contents thereof and that the same is true of his own knowledge except as to the matters therein stated to be alleged upon information and belief, and as to those matters he believes it to be true.

(Sgd.) ROY E. SWENEY.

Sworn to and subscribed before me this 20 day of May, 1930.
[NOTARIAL SEAL.] (Sgd.) R. I. MACGEORGE,
Notary Public.

Notary Public, N. Y. Co. No. 573; N. Y. Co. Reg. No. 1–M–734; Bronx Co. Clerk No. 76; Bronx Co. Reg. No. 3122–B. Commission expires March 30, 1931.

Answer

(Filed May 26, 1930)

In the District Court of the United States for the District of Delaware

Equity No. 789

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Now comes the defendant above named and answers plaintiff's bill of complaint as follows:

I. Defendant admits the allegations contained in Paragraph I of the bill of complaint.

II. Defendant admits the allegations contained in Paragraph II of the bill of complaint.

III. Defendant denies each and every of the allegations contained in Paragraph III of the bill of complaint.

IV. Answering Paragraph IV of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

V. Answering Paragraph V of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

VI. Answering Paragraph VI of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

VII. Answering Paragraph VII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters alleged in the first two sentences therein, and therefore neither admits nor denies the same, but leaves the plaintiff to make

such proof thereof as it may be advised if the allegations in said two sentences are deemed material. The defendant denies each and every of the other allegations contained in said paragraph numbered VII.

VIII. Answering Paragraph VIII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters alleged in the first sentence therein, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said sentence are deemed material. The defendant denies each and every of the other allegations contained in said paragraph numbered VIII.

IX. As to the matters alleged in Paragraph IX of the bill of complaint, defendant admits that on March 21, 1922, one Percival D. Lowell and Francis W. Dunmore filed application for United States letters patent and secured thereon on November 9, 1926, letters patent of the United States numbered 1606212. As to all other matters in Paragraph IX the defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

X. Defendant denies each and every of the allegations contained in Paragraph X of the bill of complaint, and defendant further alleges that no officer or agency of the United States Government was or is authorized to acquire the invention of the Letters Patent 1606212 on behalf of the Government.

XI. Answering Paragraph XI of the bill of complaint, defendant admits that a license was granted to it under Letters Patent 1606212, and defendant denies each and every of the other allegations contained in said Paragraph XI.

XII. Answering Paragraph XII of the bill of complaint, defendant admits that it has at various times collected and received various sums of money from divers persons as royalties or license fees in connection with and arising out of letters patent numbered 1606212, but defendant denies that any of the said money belongs to plaintiff and denies that it holds the said money or any other property for the benefit of the plaintiff.

XIII. Answering Paragraph XIII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same, but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

XIV. Answering Paragraph XIV of the plaintiff's bill of complaint, defendant denies the allegations contained therein.

Wherefore, having duly answered the bill of complaint, this defendant denies that the plaintiff is entitled to the relief demanded or to any part of the same, and prays that the bill of complaint be dismissed with costs.

DUBILIER CONDENSER CORPORATION,
By (Sgd.) ROY E. SWENEY,
Secretary-Treasurer.
JAMES H. HUGHES, Jr.,
Solicitor for Defendant.

STATE OF NEW YORK,
County of Bronx, ss:

Roy E. Sweney, being duly sworn, deposes and says that he is secretary-treasurer of the Dubilier Condenser Corporation, the defendant in this suit, that he has read the foregoing answer to the bill of complaint in this suit and knows the contents thereof, and that the same is true of his own knowledge except as to the matters therein stated to be alleged upon information and belief, and as to these matters he believes it to be true.

(Sgd.) ROY E. SWENEY.

Subscribed and sworn to before me this 20th day of May, 1930.
[NOTARIAL SEAL.] (Sgd.) R. I. MAC GEORGE,
Notary Public.

Notary Public, N. Y. Co. No. 573; N. Y. Co. Reg. No. 1–M–734; Bronx Co. Clerk No. 76; Bronx Co. Reg. No. 3122–B. Commission expires March 30, 1931.

Answer

(Filed May 26, 1930)

In the District Court of the United States for the District of Delaware

Equity No. 790

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Now comes the defendant above named and answers plaintiff's bill of complaint as follows:

I. Defendant admits the allegations contained in Paragraph I of the bill of complaint.

II. Defendant admits the allegations contained in Paragraph II of the bill of complaint.

III. Defendant denies each and every of the allegations contained in Paragraph III of the bill of complaint.

IV. Answering Paragraph IV of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

V. Answering Paragraph V of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

VI. Answering Paragraph VI of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

VII. Answering Paragraph VII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters alleged in the first two sentences therein, and therefore

neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said two sentences are deemed material. The defendant denies each and every of the other allegations contained in said paragraph numbered VII.

VIII. Answering Paragraph VIII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters alleged in the first sentence therein, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said sentence are deemed material. The defendant denies each and every of the other allegations contained in said paragraph numbered VIII.

IX. As to the matters alleged in Paragraph IX of the bill of complaint, defendant admits that on February 27, 1922, one Francis W. Dunmore filed application for United States letters patent and secured thereon on February 5, 1927, letters patent of the United States numbered 1635117. As to all other matters in Paragraph IX the defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

X. Defendant denies each and every of the allegations contained in Paragraph X of the bill of complaint, and defendant further alleges that no officer or agency of the United States Government was or is authorized to acquire the invention of the Letters Patent 1635117 on behalf of the Government.

XI. Answering Paragraph XI of the bill of complaint, defendant admits that a license was granted to it and to the Morkrum Company under the letters patent number 1635117, and defendant denies each and every of the other allegations contained in the said Paragraph XI.

XII. Answering Paragraph XII of the bill of complaint, defendant admits that it has at various times collected and received various sums of money from divers persons as royalties or license fees in connection with and arising out of letters patent numbered 1635117, but defendant denies that any of the said money belongs to plaintiff and denies that it holds the said money or any other property for the benefit of the plaintiff.

XIII. Answering Paragraph XIII of the bill of complaint, defendant says that it has no knowledge sufficient to form a belief of the matters therein alleged, and therefore neither admits nor denies the same but leaves the plaintiff to make such proof thereof as it may be advised if the allegations in said paragraph are deemed material.

XIV. Answering Paragraph XIV of the plaintiff's bill of complaint, defendant denies the allegations contained therein.

Wherefore, having duly answered the bill of complaint, this defendant denies that the plaintiff is entitled to the relief demanded or to any part of the same and prays that the bill of complaint be dismissed with costs.

DUBILIER CONDENSER CORPORATION,
By (Sgd.) ROY E. SWENEY, *Secretary-Treasurer.*
(Sgd.) JAMES H. HUGHES, Jr.,
Solicitor for Defendant.

STATE OF NEW YORK,
County of Bronx, ss:

Roy E. Sweney, being duly sworn, deposes and says that he is secretary-treasurer of the Dubilier Condenser Corporation, the defendant in this suit, that he has read the foregoing answer to the bill of complaint in this suit and knows the contents thereof and that the same is true of his own knowledge except as to the matters therein stated to be alleged upon information and belief, and as to these matters he believes it to be true.

(Sgd.) ROY E. SWENEY.

Sworn to and subscribed before me this 20th day of May, 1930.

[NOTARIAL SEAL.] (Sgd.) R. I. MACGEORGE,
Notary Public.

Notary Public, N. Y. Co. No. 573; N. Y. Co. Reg. No. 1–M–734; Bronx Co. Clerk No. 76; Bronx Co. Reg. No. 3122–B. Commission expires March 30, 1931.

CONDENSED STATEMENT OF PROCEEDINGS

In the District Court of the United States for the District of Delaware

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

In Equity Nos. 788, 789, 790

Wilmington, Del., October 7, 8, 9, 10, 1930

Before: Hon. JOHN P. NIELDS, United States District Judge.

Appearances: Charles B. Rugg, Esq., Alexander Holtzoff, Esq., Arthur B. York, Esq., Frank J. Keating, Esq., Leonard E. Wales, Esq., for the plaintiff; James H. Hughes, jr., Esq., E. Ennalls Berl, Esq., John B. Brady, Esq., for the defendant.

Plaintiff's evidence

The following exhibits were offered in evidence by Mr. Holtzoff:

Certified copy of letters patent of United States issued to Francis W. Dunmore on July 5, 1927, No. 1635117, entitled "An Improvement in Signal Receiving Systems," which was received in evidence and marked "Plaintiff's Exhibit No. 1."

Certified copy of letters patent of United States, No. 1455141, granted to Percival D. Lowell and Francis W. Dunmore on May 15, 1923, entitled "Improvement in Radio Receiving Apparatus," received in evidence and marked "Plaintiff's Exhibit No. 2."

Certified copy of letters patent of the United States issued to Francis W. Dunmore and Percival D. Lowell, No. 1606212, and granted on November 9, 1926, entitled "Improvement in Power Amplifiers," received in evidence and marked "Plaintiff's Exhibit No. 3."

Certified copy of the Patent Office file wrapper and contents relating to patent No. 1635117, received in evidence and marked "Plaintiff's Exhibit No. 4."

Certified copy of the Patent Office file wrapper and contents relating to patent No. 1455141, received in evidence and marked "Plaintiff's Exhibit No. 5."

Certified copy of the Patent Office file wrapper and contents covering patent No. 1606212, received in evidence and marked "Plaintiff's Exhibit No. 6."

An agreement dated October 20, 1924, between Dubilier Condenser and Radio Corporation on the one hand and Francis W. Dunmore and Percival D. Lowell on the other, the same being the exclusive license granted to the Dubilier Condenser Corporation relating to patent No. 1455141, which was received in evidence and marked "Plaintiff's Exhibit No. 7."

It was stipulated that the name of the defendant corporation was afterwards changed from Dubilier Condenser and Radio Corporation to Dubilier Condenser Corporation. (Offering of exhibits in evidence continued.)

An agreement entered into between Dubilier Condenser Corporation on the one hand and Francis W. Dunmore and Percival D. Lowell on the other, dated May 19, 1927, received in evidence and marked "Plaintiff's Exhibit No. 8," being the exclusive license in so far as patent No. 1606212 is concerned.

An agreement dated July 15, 1927, between Dubilier Condenser Corporation and Francis W. Dunmore, the exclusive license relating to patent No. 1635117, which was received in evidence and marked "Plaintiff's Exhibit No. 9."

HUGH GATES BOUTELL, having been duly sworn, was examined and testified as follows:

Direct examination:

I reside in Washington and hold the position of chief of information section of the Bureau of Standards, which position I have held since July, 1919.

The functions of the information section of which I am chief are that we act as a sort of a liaison office between the scientists and technical men at the bureau and the public and tried to keep the public informed of what the bureau is doing through personal contact with visitors, answering telephone calls, replying to letters and looking after the distribution of various scientific and technical reports.

I am in charge of this work and have been in charge of it since July, 1919.

Referring to the Bureau of Standards as it existed in 1921 and 1922, a brief outline of the method of organization of the bureau is that at that time the bureau had a director's office and under that a group of technical divisions, each under a division chief, and a group of three divisions dealing with the internal workings of the bureau, the shop, office, and the plant. Each division dealt with a broad class of work.

Q. Will you state what the general functions were of these divisions?

Mr. HUGHES. I think I will object to that, if your honor please. It seems to me calling for a conclusion there. I do not know just what Mr. Holtzoff means by functions, but we shall have to hear something about the functions of the Bureau of Standards, and I do not want any confusion of that term "functions."

Mr. HOLTZOFF. If you do not like the word "function," I will ask the witness to state in a general way what the various divisions did.

The WITNESS. They keep very busy, for one thing, on scientific and technical work.

Mr. HUGHES. I object. That is not responsive.

The COURT. Shall we have some ruling on this? It seems to me that this is a pertinent query.

Mr. HUGHES. I have no objection to the question, but I object to the answer.

The COURT. The objection is overruled.

Mr. HUGHES. Exception.

The COURT. Let the exception be noted.

The WITNESS. The divisions carry on scientific and technical research work and also some routine testing, about half of that for the Government and half of that for the public.

In 1921 there were nine technical and scientific divisions, the same being the division of electricity, division of weights and measures, division of heat and thermometry, optics, chemistry, engineering, physics, structural engineering, and miscellaneous materials, metallurgy, ceramics, and three belonging to the internal work of the department.

Each of the nine divisions carry out scientific and research work and testing work in the general field indicated by the name of the division. For instance, the field of work of the electrical division covered the following; that is, it was made up of a certain number of sections which dealt with specific work, and the field work of the division is indicated by giving the name of the section. The names of the various sections of the electrical division are the resistance measurements section, inductance and capacity, electrical measuring instruments, magnetic measurements, photometry and illuminating engineering, radio communication, electric batteries, radio activity and X-ray measurements, electrolysis prevention, safety engineering and standards, gas engineering, electrical and related service standards, and telephony.

There was a section of the division in charge of each of these groups of work, each section being organized under the direction of a section chief, who was responsible to the division chief, while the division chief in turn was responsible to the director of the bureau.

Taking the other eight divisions, they are likewise subdivided into sections, each section being headed by a section chief who is responsible to the division chief, and each division chief being responsible to the director of the bureau.

Q. Did I understand you to say that the various divisions and sections carried on research work in their respective fields and also testing work?

Mr. HUGHES. If the court please, I want to enter a general objection to this line of inquiry. Here is a governmental bureau sustained under certain acts of Congress. We are not interested in what they did, but we are interested in what they had legislative constitutional power to do. I object unless this man can show that what they did was such work. This is a bureau established by an act of Congress in 1901; its functions and duties and its field is defined. Unless Mr. Boutell can show that what they did came to them in the field of the Bureau of Standards, I do not think it is of any interest to the court, and I do not think he is qualified to testify. I want to make that general objection to all the testimony of this witness.

The COURT. It appears to the court that it is appropriate to know what they did. If they acted beyond their powers you will so advise us, but I think this witness may testify as to what this section did.

Mr. HUGHES. Of course, there is a lot of soundness in what your honor says except this, that we are trying here a bill for specific performance, and the burden is peculiarly on the plaintiff to prove his case. It is not the burden of the defendant to disprove a case until the case is made. I think it is the affirmative burden of the Government to show whatever was done in this bureau had the authority of law.

The COURT. That objection is overruled.

Mr. HUGHES. May I have an exception?

The COURT. Certainly. Note an exception.

A. Yes.

The testing work of the bureau consisted of the routine examination or measurement of material or devices sent there, the work itself not being new work or necessarily along new lines. I should say that about half of these materials and devices received for testing were from various branches of the Federal Government, and half of them probably from private industries and the public.

Q. Were the two kinds of work; that is, research work and testing work, carried on in the same division or were there separate groups and divisions for the two kinds of work?

Mr. HUGHES. I want to note my same objection to that question, that it must be prefaced in established authority under the organic acts under which this bureau operates.

The COURT. Objection overruled. The objection and exception is noted.

A. The same men do both kinds of work at the bureau, both research work and testing work. There is no hard and fast distinction. Taking the electrical division and its various sections, for instance, any testing and any research work relating to electricity will all be done by the electrical division and the particular section of the division to which that kind of work relates. The same men carry on both kinds of work. In many cases it would be a pity to use good research men on testing, but they are shifted around, depending on the volume of the two kinds of work. I have here an organization chart showing the organization of the bureau, and I will hand it to you. I will try to explain this chart.

This is the director's office and these are the groups of the divisions of the bureau. Each of these is a major group—electricity, weights and measures, and so on. Under that main heading we find the sections which are subdivisions of the main division. Each of the columns represent divisions. The first column represents the electrical division. Each of the blocks in that column represents one of the sections in that division. The sixth block in that column is the radio section of the electrical division, headed by Dr. J. H. Dellinger.

Likewise the other columns represent the various sections composing each of the other divisions, and this chart also shows the working divisions of the bureau, the office, and the shops and the plant. There is a Roman numeral for the division and an Arabic numeral for the section.

Mr. HOLTZOFF. I offer this chart in evidence.

The COURT. Any objection, Mr. Hughes?

Mr. HUGHES. I do not see any objection.

The COURT. Received.

Mr. HUGHES. May I ask if that chart was in existence in 1921?

The WITNESS. Not that particular chart; no, sir.

Mr. HUGHES. Then I ask leave to withdraw my statement. I think that the chart in existence in 1921 should be introduced, if any. When was this chart compiled?

The WITNESS. This is kept up to date from month to month and that last one bears a date on it in the corner, August, 1930.

Mr. HUGHES. This is 1930, and I think its lack of probative value is obvious.

Mr. HOLTZOFF. May I ask the witness a question or two on this point and, perhaps, clear up the difficulty?

Mr. HUGHES. Yes.

By Mr. HOLTZOFF:

Q. Was there any difference in the scheme of organization of the bureau as it existed on August 2, 1930, which appears to be the date of this chart, and as it existed in 1921 and 1922?

A. No difference in scheme.

Q. Was there any difference in the specific divisions and sections between the two dates?

A. Yes.

Q. What were the differences?

A. I could not tell you all of those. There have been certain sections added to other divisions and certain taken away. They are shifted back and forth since then, but the main nine divisions are the same and in the electrical division down to number section 10 they are the same. In fact that line-up of the electrical division is the same as it was at that time. As far as that goes there were three other sections below No. 10 at that time.

Q. Are there any divisions added or subtracted?

A. Yes; there is a group shown here that did not exist at all at that time, the commercial standardization.

Q. The other nine divisions headed research and testing were in existence in 1921 as they were on August 2, 1930?

A. Yes, sir.

Q. With the same names?

A. No; not exactly the same names.

Q. Were there any substantial differences?

A. Slight differences. I would not call it a substantial difference.

Q. What were the differences?

A. Electricity, weights and measures, heat and theremometry—and now we call it heat and power——

Mr. HUGHES. I withdraw my objection. I think that scheme is substantially the same in both years.

(Received in evidence and marked "Plaintiff's Exhibit No. 10.")

By Mr. HOLTZOFF:

Q. Mr. Boutell, can you give an illustration to the court of some of the research projects that were carried on or developed by the Bureau of Standards in its various divisions prior to 1922?

Mr. HUGHES. I object unless he can show that those projects or efforts were authorized by law under the organic act of the bureau.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be noted. These illustrations are to illustrate the functioning of the bureau.

Mr. HOLTZOFF. Yes.

The COURT. And the general character?

Mr. HOLTZOFF. Yes.

A. (Continued.) At that time there was some difficulty with the corrosion of underground pipe lines in certain cities, due to stray currents from street railways where they used the track for the return current, and sometimes it jumps off to a pipe line and corrodes the pipe. They developed an earth current meter for measuring the intensity of the current discharged from a pipe at any point and they said it was a very good measure of the degree of corrosion going on there. That was one thing.

Mr. HUGHES. I ask that the last part of the answer be stricken out, which is admittedly hearsay.

The COURT. Objection sustained. Let the hearsay portion of the answer be stricken out.

A. (Continued.) A machine was developed for giving a service test to automobile brake linings. The Quartermaster Corps asked the bureau to write a specification for brake linings for automobiles. Before they could do it they had to see how they could test them.

Mr. HUGHES. Did the Quartermaster Corps put that request in writing?

The WITNESS. Yes, sir.

Mr. HUGHES. I object unless the written request is offered.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be noted.

A. (Continued.) Before we could write a specification we had to find out how to test them. Nobody seemed to know how to test them. A machine was developed for testing automobile brake linings and giving them a test, and blue prints were furnished to brake-lining manufacturers and as a result of that the linings were considerably improved and we saw a great improvement after that test was developed.

By the COURT:

Q. By whom was that request made?

A. By the Quartermaster Corps of the Army. A process was developed for dextrose recovery, and that has grown into a large industry. They had difficulty in recovering sugar, and by the water crystallization process the bureau made that possible, and it is now used.

Mr. HUGHES. I must ask that that be stricken out unless the authority for the work on that dextrose process is shown. My objection to this line of testimony is this: Here we have a statutory body, and this is not a manufacturing plant which does what it pleases, but here is an organization which must operate within the scope of its

functions. It can not be of any probative value to have testimony put in as to what this organization did unless it is first shown that what it did was within the line of its authority.

The COURT. I think it is pertinent.

Mr. HUGHES. May I have an exception?

The COURT. Certainly. Proceed.

The WITNESS. At one time there were many accidents with elevators, due to failure of the door to close at the time when the car was not there, and the starting of the car before the door was closed, and elevator interlocks came in to prevent those accidents. The bureau developed a special machine to test those interlocks and it is still in use, and prepared a code giving definite requirements. These requirements did not exist before.

Then it developed a special secret signalling system for use by the Ordnance Department of the Army. They use infra-red rays, which you can not see at all, by means of lights and mirrors used for signal purposes. They assisted in the development of a hydraulic gear for synchronizing the fire of aeroplane machine guns through the propeller so that the blade would not be there when the gun was fired, otherwise you would shoot the blade off.

Mr. HUGHES. May I have the same objection to that? If I may, I would suggest that I note this objection to all of this line of testimony so that I will not have to repeat it in every instance.

The COURT. Certainly.

Mr. HUGHES. May I have it understood that this objection runs to the whole line?

The COURT. Yes; the objection and exception.

The WITNESS. There is one more piece of work that I recollect; that was the development of the optical-glass industry in this country. Prior to the war we did not make any optical glass; we had some fine lens makers, but there were none made in this country, and the bureau assisted the Government in the development and technique of making fine optical glass, so that towards the end of the war they were actually making a good grade of glass there at the bureau. We have continued that work since that time. That involved a new method of making pots, in which the glass is melted, big pots holding a thousand pounds of glass, made in a casting process. I do not know that I can recollect anything else at this time. I know that there were other research projects carried on in the bureau and other developments made besides the ones I have mentioned but I can not recollect what they were.

In 1921 and 1922 the Bureau of Standards published the results of original research work which were issued in two series of papers or in outside publications with the authority of the bureau. The two

series of papers published by the bureau were known as Scientific and Technologic. A description of a purely scientific piece of apparatus would be published in one of the scientific papers. If it was a fire test of building columns, or something like that, then that would be published as a technologic paper. Then there were circulars——

Mr. HUGHES. Pardon me, may I note the same objection, for the same reason that I noted to the instances before, the same objection to the publications, unless it is shown that the publications were authorized publications.

The COURT. The same ruling and exception is noted.

The WITNESS. Results of work not original with the bureau were published as circulars. If a man got together all the literature on helium, we will say that he had published a big bibliography of that, then that would be published as a circular. If we published a recommended code for safety work, such as proper procedure in running wires through cities and telephone wires over other telephone wires that would be published in a handbook series. Big charts that could not be bound up in papers were in miscellaneous papers. There were those series at that time, and then there were papers published outside in the scientific and technical press.

There was also a monthly series that was issued every month, a small bulletin known as the Technical News Bulletin, containing informal accounts of progress of the work in the laboratories.

The various publications to which I have referred were prepared by the man or individual who did the work. In publishing such papers the course of procedure that was followed was that the individual submitted his draft to his superior officer, generally the sectional chief, and after he read it and approved it, it would then go to the division chief and occasionally in some divisions to a division editorial committee composed of the senior men of the division, who would read it. If they approved it, it went to the bureau editorial committee, a committee composed of men drawn from the various divisions in the bureau, and sometimes they would submit it to one or more readers to go over it, and then if they approved it, it was passed on to the director, and he approved it for publication.

Some of the papers were published in outside periodicals or journals, and papers of this nature also followed the same course of procedure that I have outlined for publications of the bureau.

Cross-examination:

By publications of articles not original articles I mean that if a man wanted to issue a collection of information for the convenience of engineers on a subject such as light alloys, such as aluminum, he could go to many different sources to find out all the details about

those light alloys, and he would put those together in one place, whereas before, the information might have been scattered through many sources, and the bureau would then issue that as a circular with no name on it, and his name would not appear on it. The Bureau of Standards paid for the publication of the circular, but I do not know under what authority; however, I presume, under the authority of the organic act creating the bureau.

In 1921 there was no section known as the transformer section. Dr. Curtis was chief of the section known as inductance and capacity. The chief of the electrical measurement section in 1921 was Dr. H. B. Brooks. Mr. K. H. Logan was chief of the electrolysis in 1919, 1920, and 1921.

The chief of the radio section in 1919 was Dr. J. H. Dellinger, who took over the work from Dr. Kolster in July of that year. I did not know that Kolster was chief of that section. During the war it was split into A and B, and sometimes he was put down as being in charge of B work, but I did not know that he was the section chief.

Dr. Dellinger was in charge of the other section but I do not think that B was a section. It was sort of a subdivision. I could not tell you when Dr. Dellinger became chief of the section but I do know that he was chief of the section in 1921.

JOHN H. DELLINGER, being first duly sworn, was examined and testified as follows:

Direct examination:

I reside at 6607 Delafield Street, Chevy Chase, Maryland. I am a physicist in the employ of the United States Bureau of Standards, being chief of the radio section.

I was appointed chief of one of the subdivisions of the radio sections in 1919 and subsequently when that section was combined into a single unit, about February, 1921, I was made chief. I have been connected with the Bureau of Standards since 1907, first with the resistance section and next with the inductance and capacity section, next with an unnamed section, I being the whole section, and finally with the radio section.

I became connected with the radio section sometime before 1917 because while in this unnamed section my duties were to a considerable degree radio, although I had some other duties and it was about 1917 when I became a part of the radio section.

I have the scientific degrees of bachelor of arts and doctor of philosophy in physics which I received from Princeton University. I am a member of the American Physical Society, Institute of Radio Engineers, and International Union of Scientific Radio, having been an officer of the last two mentioned societies.

I have occupied the office of vice president and president and a member of the board of direction of the Institute of Radio Engineers, and I am technical secretary of the American section of the International Scientific Radio Union. I have been a member of the following international congresses and conferences: Inter-allied Radio Conference held in Paris, 1921; the International Geo-physical Union, held in Prague in 1927; the International Electro-technical Commission, held in Italy in 1927, and again in Scandinavia in 1930; the International Radio Conference in Washington in 1927; the International Technical Consulting Committee on Radio, held in The Hague, Holland, in 1929; and I have also attended various national conferences and congresses of various societies.

Q. Now, looking back to 1920 and 1921 and 1922, can you describe briefly just what the radio section was doing at that time?

Mr. HUGHES. I object, if the court please, unless it is shown it was doing what it was authorized to do.

The COURT. The witness is neither a lawyer nor judge, and his judicial function I think he can not exercise. Let the objection and an exception be noted. Objection overruled.

A. The radio section in those years was carrying on work of the standardization of radio devices, of testing of radio devices, and on research upon radio devices and methods.

The funds with which this work was done was procured in part direct from appropriations to the bureau by Congress and in part by allotments from other Government agencies to the bureau.

Q. In the event of work which was paid for by contributions by other Government departments, how were the problems to be worked on selected?

A. In general——

Mr. HUGHES. Has there been nothing to show that any work was done for the Government other than the departments? I do not recall.

Mr. HOLTZOFF. He has just stated, Mr. Hughes.

Mr. HUGHES. That there were appropriations?

Mr. HOLTZOFF. That some of the work was paid for by congressional appropriations, and other work was paid for by allotments from other departments.

Mr. HUGHES. But not for *other* departments.

The COURT. Proceed.

The WITNESS. In general——

The COURT. Did you enter an objection, Mr. Hughes?

Mr. HUGHES. Yes, sir.

The COURT. The objection is overruled.

Mr. HUGHES. Exception.

The COURT. Exception will be noted.

A. In general, the nature of the work desired by the other department or agency was stated by it.

In the case of work that was paid for by direct appropriations to the bureau from Congress, the problems to be worked on were selected in a variety of ways. They were selected immediately, most commonly by the choice of the chief of the radio section, from his knowledge of the general purpose of the work desired, and sometimes by direction of the chief of the division of which the radio section was a part. I am not quite clear whether there were cases where the director himself specified the particular problems to be covered. Frequently the members of the section suggested to me, as chief, problems to be worked on and at times I selected such problems so suggested.

In 1920, up to about February, 1921, the radio section was divided into two subsections, the larger one being called, if I remember correctly, the radio research, and the other radio development. After about February, 1921, the section was a single unit with a section chief and was subdivided into groups each having a group chief and specific groups of problems were assigned to the various groups. At this time I think there were about twenty technical persons employed in the section beyond which there were some clerks and mechanicians and similar employees.

In addition to the research and development work to which I have testified, testing work was also done by the radio section. This testing work comprised the comparison with our standards of instruments, or devices sent into the bureau for standardization by other Government departments or private agencies or individuals. There was no strictly sharp division of personnel with respect to whether the same scientific employees that did the testing work also did the research and development work. It depended upon the nature of the task to be performed. I believe, if I recall correctly, one of the groups was designated the testing group and did handle the major portion of the testing.

I have a paper here which is an outline of the organization of the radio section dated July 29, 1921. It is a brief statement of the subjects of work of the several groups of the section and a list of the men working on them.

The first column shows a list of the subjects upon which the several groups were working and in some places includes under a subject a project number. I know this from reading the paper before me. This paper was prepared by Mr. L. E. Whittemore, alternate chief of the radio section.

The paper was prepared under my general direction in that outlines of this kind were prepared from time to time either by Mr. Whittemore or myself, or possibly some other assistant who was assisting me in administration matters. At the particular time when this outline was prepared I was in Europe attending one of the conferences previously mentioned and the outline was therefore prepared in my absence and could not have been under my immediate direction at that time. A brief examination of the outline indicates, according to the best of my recollection, that it is a correct statement.

Q. Now, will you look in the first line of the column, the words "Airplane radio"; what is the purpose of those words on that paper?

Mr. HUGHES. Just a minute there. Did you put those words down on that paper?

The WITNESS. I am a little confused. I have just been asked two questions. Which shall I answer first?

The COURT. The question you are to reply to is the question of Mr. Hughes.

The WITNESS. Do I remember whether it was I who put the words on this paper? I have already testified substantially that I did not.

The first entry in the first column "Airplane radio" indicates that the problems upon which the corresponding group was working were radio problems of use in connection with aeroplanes.

The next entry on the sheet is "Direction and finding."

This item "Direction and finding" indicates that the group was working on problems pertaining to a radio device which permits the determining of direction to receive radio waves.

Mr. HUGHES. I ask that that answer be stricken out. Here is testimony from a written instrument and I think it is primary that in that sort of case the instrument speaks for itself. Dr. Dellinger is not refreshing his memory from this, but he is explaining a paper not yet in evidence, a paper which if in evidence would and should speak for itself rather than be extended and expanded by oral testimony by a man who was not admittedly around when the paper was prepared.

The COURT. I think there is force in that.

Mr. HOLTZOFF. I was following this line of inquiry, because you made a suggestion before you passed upon my offer of this paper in evidence that you wanted an explanation of the first column.

The COURT. Very true. The question is whether or not this witness is qualified to explain that particular paper which should speak for itself. He was not present in this country when the paper was prepared. It was prepared by some other person and at present I rule the paper out.

Mr. HOLTZOFF. May I ask that this paper be marked for identification and I think I can produce the person who prepared it at a later stage of the trial.

The COURT. Let it be marked for identification.

(The said paper was marked "Plaintiff's Exhibit A for Identification.")

By Mr. HOLTZOFF:

Q. I show you another paper dated October 3, 1921, and ask you what that represents?

Mr. HUGHES. Before answering may I see that paper?

The COURT. Are we dealing with the records of the office?

Mr. HOLTZOFF. Yes.

The COURT. Taken from the files of the office?

Mr. HOLTZOFF. Yes.

The COURT. Why does not that give it its stamp of regularity and admissibility, Mr. Hughes? These are files and records of the office.

Mr. HUGHES. If the court please, everything that appears in a Government office is not entitled to the stamp of regularity.

The COURT. Quite true.

Mr. HUGHES. It would have to be shown first that any particular paper is such a paper and that is not certified, of course. There is a way to introduce that.

The COURT. This is an original record.

Mr. HOLTZOFF. I am producing this from the files of the department. May I go back to Exhibit A for identification?

Mr. HUGHES. My objection would be equally good. The proper witness can testify to that, but this witness can not. It is hearsay as far as this witness is concerned.

The COURT. This is the head of the department. This is part of the records of his office and the original record is produced here. On that ground I will admit the first paper.

Mr. HUGHES. May I have an exception?

The COURT. Certainly. Let an exception be entered.

(Plaintiff's Exhibit A for identification received in evidence and marked "Plaintiff's Exhibit No. 11.")

I have another paper dated October 3, 1921, which is a similar outline of the organization of the section dated October 3, 1921, which is produced here from the official files of my section.

Mr. HOLTZOFF. I offer the paper in evidence.

The COURT. Admitted.

Mr. HUGHES. Do I understand that that is subject to the same objection?

The COURT. Certainly.

Mr. HUGHES. The same objection as the paper offered immediately preceding, plaintiff's Exhibit No. 11.

The COURT. Yes.

(Received in evidence and marked "Plaintiff's Exhibit No. 12.")

The COURT. In general outline it is like the first?

Mr. HOLTZOFF. Yes.

I know Percival D. Lowell, who is a radio engineer who was employed in the radio section of the bureau at the time of which I have been speaking. I do not know exactly when he was first employed in the section, but I can say that his employment extended from some time prior to 1918 to some time in 1921. On second thought, I believe his employment continued until about the middle of 1922.

I know Francis W. Dunmore, who is a member of the radio section, having been a member since about 1918 until the present time, and he is still such a member. In 1921 and 1922 Mr. Lowell and Mr. Dunmore occupied technical positions in the section. They did not hold clerical positions. The nature of their work was radio research and development work.

I have a paper here which is dated February 23, 1921, which is a guide to the radio laboratory prepared for aid in showing visitors the things of interest in the radio building.

It is an official document of the section, although I can not say specifically whether this is the file copy or just a copy. The particular copy in my hands appears to be a mimeograph copy. What I mean is, I am not sure whether this particular mimeograph copy is the official copy or a duplicate.

Mr. HOLTZOFF. I offer this paper in evidence.

Mr. HUGHES. I object.

The COURT. On what ground, Mr. Hughes?

Mr. HUGHES. On the ground that there is no evidence here or this paper is not identified in the way the other two were. It is not testified that it is an original document of the bureau, and there is no qualification shown here of this witness that he knows who prepared it or anything of that sort. The grounds upon which the other papers were introduced are admittedly absent in this case.

The COURT. I think there is a distinction. That is a copy and purports to be such and it is not certified by any person qualified to make such a certification.

Mr. HUGHES. Mr. Holtzoff, unless you want to examine on that at some length, let me go over that. I want my objection to stand at the moment, but I might change my position after I have had time to examine it. I am not acquainted with this paper, and I can not afford not to object to any paper unless I know just what it is. I will look it over during the lunch hour.

Mr. HOLTZOFF. In the meantime I can go on to something else.

Mr. HUGHES. You will loan this to me temporarily?

Mr. HOLTZOFF. Surely.

By Mr. HOLTZOFF:

I have a document here entitled "Information for Members of the Radio Laboratory," dated July 16, 1920, which was prepared by me. It bears both my initials and a facsimile of my signature.

Q. What was the purpose of this document?

Mr. HUGHES. I object. What is the authority, first, for the document? I am interested in that.

Mr. HOLTZOFF. My question is what was the purpose of the document.

Mr. HUGHES. In the line of your question, I object to any questioning from this paper until it is established that it is an authorized paper or document or publication made by this officer acting under organic acts of Congress.

The COURT. You revert to the earlier objection?

Mr. HUGHES. Yes.

The COURT. This witness is not judicial, and he is simply testifying to facts, and your objection is overruled.

Mr. HUGHES. May I have an exception?

The COURT. Certainly.

A. This is a document which was prepared to give information to the members of the section on various matters of procedure and activity and was as a matter of routine given to each new employe when he came into the section for that purpose.

Mr. HOLTZOFF. I offer this document in evidence.

Mr. HUGHES. I object, if the court please.

The COURT. Is that an exact copy of the paper which you yourself prepared?

The WITNESS. Yes.

By Mr. HUGHES:

X Q. Was a copy of that given to Mr. Lowell and Mr. Dunmore?

A. A copy was given as a matter of routine to all of the members of the section.

X Q. Did you give it to them yourself?

A. I do not remember any specific act of giving.

X Q. Who did give it to them?

A. I may have, or my office clerk may have, or the assistant chief may have.

X Q. Can you testify that that copy ever came into the hands of either Dunmore or Lowell?

A. I can testify on the practice and can not testify of any recollection in a case of any particular individual.

Mr. HUGHES. I object. This can have no probative effect of any sort, unless it is brought to the attention of these two technicians. The doctor can not testify that that was done.

The COURT. Has he testified with reference to the general instructions with reference to the distribution of this document?

By Mr. HOLTZOFF:

Q. Did you give any general instructions to your subordinates as to the distribution of this document?

A. I instructed the chief clerk of the office to give it to each new employee along with other routine matters which were brought to the attention of new employees.

Mr. HUGHES. Here is something that the Government thinks obviously affects the issues in this case. It is what appears to be an unofficial publication, which it deems to be probative as affecting these two inventors. Certainly before that can be admitted that paper must be shown to have been brought to the attention of these two men. Dr. Dellinger says it was given to the new members coming in. These were not new members.

By Mr. HOLTZOFF:

Q. Were any instructions given by you in reference to any distribution of copies of this paper to old members of the section or members of the section who were in the section at the time this document was prepared?

A. At the time that I became chief of the combined section I took it upon myself to organize the section a little more—to coordinate the work of the two sections, and took means to inform all of the members of matters of procedure, and I can not state with certainty, because I do not have the specific recollection, but believe as a matter of course or part of that general routine, I had a copy given to each member who came into the section at that time.

Mr. HUGHES. I move that that be stricken out. He states that he cannot remember that it was done, but he believes that it was. That is far and away from the testimony touching on a vital point in this case. Certainly the Government cannot build a case on evidence of that far-fetched kind.

The WITNESS. Would it be proper to supplement my former statement?

The COURT. There is no objection to his supplementing his answer by anything.

The WITNESS. I do not remember whether this was the first issue of this document or one of a number of revisions which there were from time to time. When the first compilation of these procedural matters was prepared it was given to all members of the radio section, and I am not clear as to whether it was prepared during the

time that the section was split up into two parts, but I do have a general recollection that it was distributed to all members of the section, whether or not they were in either of the two parts, so that when it was originally prepared it went to every one and thereafter to all newcomers.

Mr. HUGHES. May I inquire of the witness here?

The COURT. Yes.

By Mr. HUGHES:

X Q. Did you, when there were two sections before they were united, personally distribute this to the members?

A. I do not remember.

X Q. Do you have any positive recollection that you personally brought this memorandum to the attention of either Lowell or Dunmore?

A. No such positive recollection.

The COURT. These were general instructions that you issued to all members of that group?

The WITNESS. To all members of the section.

The COURT. Do you offer those instructions in evidence?

Mr. HOLTZOFF. Yes.

The COURT. They are admitted.

Mr. HUGHES. I object to the admission.

The COURT. Let the objection be noted.

Mr. HUGHES. And exception.

The COURT. Let the exception be noted.

(Received in evidence and marked "Plaintiff's Exhibit No. 13.")

The WITNESS. I have a document here dated February 26, 1920, entitled "Preparation of Papers," which is a compilation of information intended to be useful to members of the section in preparing papers for publication. This paper was prepared by me and it bears my initials. I caused it to be distributed among some or all of the members of the section. There were some matters of procedure and some documents covering procedure which I caused to be distributed only to the chiefs of the several groups, and I am not certain whether this was distributed to all of the members of the section or only to the group chiefs. I am inclined to think, if it is appropriate to mention what I am inclined to think, that it went to all of them because I felt that it was useful.

Mr. Dunmore was a group chief, but I am not certain whether Mr. Lowell had the status of a group chief or not, but, in general, Mr. Lowell was an individual worker, and, without refreshing my memory by reference to the record, I can not say whether he had the status of a group chief, but Mr. Dunmore was. I am sure that I

caused this document to be distributed among the group chiefs, if not to all the members of the laboratory.

Mr. HOLTZOFF. I offer this document in evidence.

The COURT. For the purpose of affecting Mr. Dunmore, the document is admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 14.")

By Mr. HOLTZOFF:

Q. Of what group was Mr. Dunmore chief?

A. Airplane radio group.

Q. And what were the duties of that group?

Mr. HUGHES. I object to that until it is shown that those duties were authorized by the organic act constituting this organization.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

A. The duties of the group were to carry on research and development work on airplane radio problems. I would like to add that the group assignments were shifted from time to time and at any one time were not divided into as water-tight compartments as perhaps the outline which we have previously seen would indicate, but the major function of this group was to work on particular problems on the use of radio in connection with aircraft.

During this period the headquarters of my section was in the radio building of the Bureau of Standards. There were a number of laboratory rooms under the control of my section and they all were a part of the radio section.

The rooms taken jointly were commonly referred to as the radio laboratory and the research work of the members of my section was done in the radio laboratory, although some of the work was done out of doors where large scale work would make it more convenient to work outdoors and in some cases apparatus would be mounted on an automobile and taken to some point.

The Bureau of Standards is located in the northwest part of Washington, D. C., the radio building being a part of the group of buildings that form the Bureau of Standards. The radio laboratory was located in the radio building.

All technical members or all members of the laboratory staff kept a record of day to day work on cards which were turned into the office weekly. They also prepared a monthly report which was turned into the office and in cases where it seemed useful many of the members of the laboratory kept a laboratory notebook in which they made entries from time to time of results, developments, or notes. The members of the laboratory were required to keep the report cards to which I have referred, containing daily entries as

to the work done by them in the laboratory on each day, and the keeping of them was not optional with the members.

These weekly report cards were filed in the office of the section weekly. There was one card for each week having a separate entry on it for each day of the week.

Each member of the laboratory was not only required to keep such a weekly report card and file it in my office at the end of the week, but they were also required to keep monthly reports which were also filed each month in my office. The laboratory notebooks to which I have referred were retained by the member of the section and there was no regular procedure with regard to filing them except that when a member left the section they were then filed in my office.

Mr. HOLTZOFF. If your honor please, we postponed until after recess, if your honor will recall, the consideration of an offer of an exhibit that I made so that Mr. Hughes might have the opportunity of glancing over it during the recess, and so I renew my offer of the paper dated February 23, 1921, entitled "Guide to Radio Laboratory, Bureau of Standards and Associated Radio Laboratories."

Mr. HUGHES. I make the same objection, if the court please, that I did to the other exhibits. I add this further objection that the Government has not shown that this time, February 23, 1921, is pertinent to the inventions in suit.

The COURT. I think it is admissible for what it is worth.

Mr. HUGHES. May I have an exception?

The COURT. Let an exception be noted.

(The same was thereupon received in evidence and marked "Plaintiff's Exhibit No. 15.")

In the spring of 1921 I had a conference at the Bureau of Standards, radio building, with Lieutenant Van Zandt, of the Air Corps of the United States Army, in reference to radio research work to be done by the bureau. Fixing the time as closely as I can, the conference was some time in the spring of 1921 prior to June of that year. I am not clear whether there was more than one discussion with Lieutenant Van Zandt in the spring of 1921. There had been a conference with him in December, 1920, and then this one of the spring of 1921 was a follow-up on that and consisted of discussions of work on airplane radio problems which the bureau was undertaking and was contemplating undertaking for the Air Service.

At the conference toward the end of 1920 we discussed the work which the bureau would do——

Mr. HUGHES. If the court please, I object to this testimony. It is an interdepartmental discussion obviously, and not brought home to the attention of the patentees, and I do not see any pertinency or

materiality as to what was said between this man and the men of other departments. It is also self-serving, and, unless brought home in the presence of these men, I do not see how it can be connected with them.

The COURT. What has this to do with the patent?

Mr. HOLTZOFF. It is my purpose to show, if your honor please, that certain research work in radio was undertaken by the Bureau of Standards at the request of the Air Service of the Army; that the Air Service of the Army allotted or contributed funds for that work and turned over such funds to the Bureau of Standards; that in pursuance to that work Mr. Dunmore was designated as the group chief to take charge of this Air Service radio-research program; and it was as a result of that that the inventions, or at least one of them involved in this suit, developed.

The COURT. Without going into the conversations, can we not have the result of the conference?

Mr. HOLTZOFF. Yes; surely.

Q. What was the result of the conference between you and Van Zandt?

A. The result of the conference was an agreement on the general outline of a program which the bureau would undertake on a number of radio problems of interest to the Air Corps, for which they contemplated transferring money to the bureau.

By Mr. HOLTZOFF:

I have here a certified copy of a letter from the Assistant Secretary of War to the Secretary of the Treasury dated June 14, 1921, that I wish to offer in evidence. The letter requested the transfer to the Bureau of Standards of $267,500 to cover the cost of certain experimental projects for the Air Service of the Army and an enclosure attached to that letter listing the projects.

(Received in evidence and marked "Plaintiff's Exhibit No. 16.")

I also offer in evidence a letter from the office of the Director of the Air Service of the War Department to the Director of the Bureau of Standards dated June 13, 1921, in reference to the same subject matter.

(Received in evidence and marked "Plaintiff's Exhibit No. 16–A.")

I offer in evidence a letter from the office of the Chief of Finance of the War Department to the Bureau of Standards dated June 14, 1921, dealing with the same subject matter.

(Received in evidence and marked "Plaintiff's Exhibit No. 16–B.")

I also offer in evidence a letter dated May 16, 1921, from the chief of the engineering division of the Air Service to the Chief of the Air Service of the Army.

(Received in evidence and marked "Plaintiff's Exhibit No. 16–C.")

I also offer in evidence a letter dated May 19, 1921, from the Director of the Bureau of Standards to Major Bane of the Air Service of the War Department.

(Received in evidence and marked "Plaintiff's Exhibit No. 16–D.")

I also offer in evidence a letter from Major Bane to the Director of the Bureau of Standards of the same date.

(Received in evidence and marked "Plaintiff's Exhibit No. 16–E.")

Mr. HOLTZOFF. All of these exhibits show the transfer of the sum of $267,500 from the Air Service of the Army to the Bureau of Standards to be expended in carrying out certain research work.

Mr. HUGHES. Do these all deal, Mr. Holtzoff, with the transfer of funds?

Mr. HOLTZOFF. Yes; transfer of funds, plus a list of the projects for which the funds were to be used.

Mr. HUGHES. Other than the notations in pencil and pen, which appear to be the notations of the Bureau of Standards, we have no objection to the admissibility of this paper.

The COURT. Subject to the qualifications suggested by Mr. Hughes, the papers are admitted.

Mr. HOLTZOFF. I offer in evidence a certified copy of a letter from the Chief of the Air Service to the chief of the engineering division dated May 25, 1921, dealing with the same subject matter.

(Received in evidence and marked "Plaintiff's Exhibit 17.")

The WITNESS. After the conferences with the representatives of the Air Service to which I have testified, in order to carry into effect the research program that was agreed upon with the Air Service, the work was included in the program of the section and as rapidly as possible when the work could be fitted into the other work we proceeded to work upon it. The work did not get going immediately in December, 1920, as I recall, but within a month or two or three after that the work first agreed upon was put into active operation in the group of the section of which Mr. Dunmore was the head, and from that time on the work of that group was primarily upon these projects for the Air Service, and in addition some work of some of the other groups was on some of these problems.

I put Mr. Dunmore in charge of the work on the Air Service projects. I have here a paper dated July 29, 1921, showing a list of the radio research projects to be carried on for the Air Service.

By Mr. HUGHES:

X Q. Doctor, you were abroad when this paper was dated?

A. Yes.

X Q. Did you draw it up?

A. No.

X Q. Were you in this country when it was compiled?

A. No.

Mr. HUGHES. I object to any testimony from this paper.

Mr. HOLTZOFF. I offer the paper in evidence. It has been testified to that it is part of the official records of the section of which Dr. Dellinger is the chief.

The COURT. I would like to have those questions repeated to properly identify this paper.

By Mr. HOLTZOFF:

Q. Is this paper taken from the official files of the radio section of the Bureau of Standards?

A. Yes.

Q. And what does this paper represent?

A. It represents a list of the several radio projects for the Air Service and an indication of the specific steps to be taken under each for carrying out the work.

By the COURT:

Q. Do I understand that that is an original paper taken from the files of your office?

A. Yes.

Mr. HOLTZOFF. I renew my offer.

Mr. HUGHES. If the court please, I do not think the paper is qualified yet as showing it was made in the regular course of the operation of the bureau, but it is simply a paper that was in the files of the bureau. It must have other attributes to make it available for evidence when it is offered by one of the parties litigant. There is nothing to show how the paper got there, what it was doing there, whether it was in the regular course of the operation of the bureau. What is shown is that this man was abroad as of the date appearing on this paper.

The COURT. As at present tendered, I think it is not admissible.

Mr. HOLTZOFF. I think I can supplement that.

By Mr. HOLTZOFF:

Q. Do you know the occasion of the preparation of this paper?

A. Yes.

Q. Will you state it, please?

A. The paper was prepared by Mr. L. E. Whittemore, alternate chief of the section who was in charge of the section while I was abroad——

By Mr. HUGHES:

X Q. Do you know that?

A. Yes.

X Q. You were there and saw it done?

A. No.

X Q. How do you know it?

A. I know it from the nature of it and from what I see on it, from the initials appearing on it and from the nature of my conferences with Mr. Whittemore both before and after my trip.

X Q. That is simply a conclusion on your part?

A. It is the kind of a conclusion which a great deal of knowledge consists of. I do not know how to describe it legally. I have stated the facts as I know them.

X Q. It is a conclusion, is it not?

Mr. HOLTZOFF. The question has been answered.

Mr. HUGHES. I was not asking for any metaphysical dissertation of what a conclusion is, but it is a conclusion on your part that it was so prepared.

The WITNESS. It is both a conclusion and a statement of my knowledge of the matter.

By Mr. HUGHES:

X Q. And what is your knowledge?

A. As I have stated before, that it was prepared by Mr. Whittemore.

X Q. You saw it done?

A. No.

X Q. Then how do you know it was prepared?

A. I do not believe I can supplement what I have already stated.

Mr. HUGHES. I do not think he can, but I do know that he has not qualified this paper.

Mr. HOLTZOFF. I have not finished my examination. You interrupted the witness's answer.

The COURT. Do I understand that the witness is testifying that this paper was made and prepared pursuant to his instructions?

By Mr. HOLTZOFF:

Q. What is the fact as to that?

A. I would not say that this specific paper was prepared pursuant to my instructions, but it was prepared pursuant to a general understanding between Mr. Whittemore and myself on the way in which we conducted the direction of the work, namely, preparing of outlines from time to time for our own convenience in keeping the work going straight.

Q. And what does this paper purport to be?

A. It purports to be an outline of work on several projects for the Air Service.

Q. Do you know whether or not it is a correct outline of the various projects and of the work to be done for the Air Service?

A. It is an outline as of this particular date. The plans for the work and the conduct of the work naturally changed as time went on.

Q. And this paper is a part of the official records of your section and is an original document?

A. Yes.

Mr. HOLTZOFF. I think I have qualified that.

Mr. HUGHES. I still object.

The COURT. The paper is admitted.

Mr. HUGHES. Exception.

The COURT. Let the exception be entered.

(Received in evidence and marked "Plaintiff's Exhibit No. 18.")

By Mr. HOLTZOFF:

Q. Dr. Dellinger, referring to the document that was just marked in evidence as Plaintiff's Exhibit 18, can you state whether or not there is any project listed in that paper which involved the development of a radio relay?

Mr. HUGHES. The instrument speaks for itself, if the court please, and I object to that question.

The COURT. There is an objection on the score that the paper speaks for itself.

Mr. HOLTZOFF. I am not asking him to testify to the contents of the paper, but the paper is a list of scientific projects and I am asking him to explain what these scientific matters stand for.

The COURT. Have you directed his attention to a particular one?

Mr. HOLTZOFF. No; I am asking him to state whether any of these projects necessitated or involved the development of a radio relay as part of the project.

The COURT. That question is objected to?

Mr. HUGHES. Yes, if the court please; on the ground that if there is anything in that paper which covers that ground it is in the paper, and the paper speaks rather than the witness.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

A. Yes; projects 42, airship bomb and marine torpedo control; and 38, visual indicator for radio signals involved the development of the radio relay.

Q. Will you explain how the development of a radio relay was involved in those two projects?

Mr. HUGHES. May I inquire if you are asking the doctor now as an expert?

Mr. HOLTZOFF. No; he is a witness as to facts.

Mr. HUGHES. May it please the court, if this examination calls for expert testimony I do not know that Dr. Dellinger has been so qualified.

Mr. HOLTZOFF. He has been qualified, but he is not called as an expert. I do not think there is much doubt about his being qualified upon this record to be an expert witness, but I am asking him to testify as to facts rather than as to opinions.

The COURT. The objection is overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

The WITNESS. In the case of project 42, airship-bomb control and marine-torpedo control, the aim in view, or one of the aims, was to produce devices by means of which a radio signal might bring about the release of a bomb or a torpedo on an airship or a ship without, of course, a person being present to operate the releasing mechanism. It was thought that an arrangement might be developed whereby the incoming radio signal could operate the relay which then in turn could very easily control the electrical circuits, the releasing mechanism, so that the problem was carried down to the relay for accomplishing the relay part of that job.

With reference to project No. 38—the visual indicator for radio signals—there the problem was less definite. The Air Service felt that if some means could be provided whereby pilots or radio operators could be relieved of listening and receive answer signals, either telegraphic or other radio signals, by means of a visual indicator, that it would be something of considerable use to them, and so they simply expressed this in this general way, and it was thought on our part that a relay which would be actuated by the incoming radio signal, or would be actuated by the current from a receiving set actuated on the incoming radio signal, would be a step towards producing such a visual device, since the relay could then in turn operate on one of several visual devices.

Q. Did Mr. Dunmore receive any instructions to develop the radio relay?

Mr. HUGHES. I think that is a leading question, if the court please. I think that Mr. Holtzoff ought to direct this inquiry that he is apparently now starting on so as to bring out the facts without suggesting the answers to the witness.

Mr. HOLTZOFF. I will be glad to modify my question, Mr. Hughes.

The COURT. Is the question withdrawn?

Mr. HOLTZOFF. It is withdrawn.

Q. Was anything said between you and Mr. Dunmore in reference to the development of the radio relay?

A. Mr. Dunmore was the group chief in charge——

Mr. HUGHES. Doctor Dellinger, may I suggest, could have first answered yes or no.

The COURT. I assume—can you make a categorical answer and then proceed with any explanation you desire?

A. I can not make a categorical reply, because I do not have memory of specific conversations.

I do not remember any specific conversations, but I do remember that in pursuance of the relation between Mr. Dunmore and myself, he being the group chief in charge of this work, there were numerous conversations on the projects under way, the general effect of which was to discuss a program of the work.

Mr. HUGHES. I ask that all that answer be stricken out except beginning with the first clause "I do not remember specifically," is a proper answer, the rest is mere conclusion, from the hazy piecing together. If the court will recall, it is necessary to establish here some kind of a contract, either expressed or implied. We are entitled to know what that contract is, if there is any such, and we are entitled to have it established, if at all, by proper evidence, properly deduced. I think that answer is improper, except the first clause.

The COURT. Have you anything to say?

Mr. HOLTZOFF. My thought is this, if your honor please: The question is not precisely one of contract; it is a legal duty. The law draws an implication that if an invention is made by an employee, as part of his functions as an employee, and in the course of his employment, why then, the invention and any patents resulting therefrom, are the property of his employer; so that we do not stand on any contractual relationship express or implied by which these individuals have agreed to convey anything to the Government. That is not our point. Our point is that the law implies a duty, irrespective of any contract, because the law says that the invention belongs to the employer. All I am trying to show is not any contract between the parties but the fact that the work that was done by these gentlemen, on this development was a part of their duties and part of their work as employees of the Bureau of Standards. That is all I am trying to show; and therefore I think this evidence is proper and relevant.

Mr. HUGHES. If the court please, all that Mr. Holtzoff says is that they are proving an implied contract growing out of the relationship, but this still is some kind of a contract, and if there is an obligation to an employee as to his duty that raises a contract.

Mr. HOLTZOFF. A contract implied in law, but not in fact.

The COURT. The objection is overruled. The testimony remains.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

The WITNESS. Mr. Dunmore worked on and developed the radio relay in the Bureau of Standards during, or largely during, the latter half of 1921.

Q. Now, was one or more than one type of relay developed?

A. Two types were developed.

Q. What were the two types?

A. One operating from direct current and the other from alternating current.

Mr. HUGHES. I move that answer be stricken out, if the court please; it is immaterial; the question was what was this man asked to do.

The COURT. Objection is overruled.

Mr. HUGHES. Exception.

The COURT. Exception noted.

Q. Was there anything said between you and Mr. Dunmore in reference to the developing of alternating-current apparatus?

A. There was, although I can not say at what stage of the work nor the specific statements.

Q. Well, as far as you can remember?

Mr. HUGHES. I ask that the answer be stricken out, if the court please.

The COURT. Objection overruled.

Mr. HUGHES. Exception noted.

Q. As far as you can remember at that time, state what was said between you and Mr. Dunmore on that subject.

A. In answering this I would like, if I may be allowed, to go back to my previous answer and further amplify and answer both together.

Q. Surely.

A. I do not have a specific recollection of conversations between Mr. Dunmore and myself on this point; but the work was managed by Mr. Whittemore and myself jointly, Mr. Whittemore being the alternate chief; and it may very well be that the conversations which I have a general recollection of bearing on this point might have been between Mr. Whittemore and Mr. Dunmore and between Mr. Whittemore and myself. All I can say is that as the work developed a number of applications began to appear other than those originally contemplated, for which the supply of the power by alternating current rather than direct current would be more useful and more definite, and that in the discussions of the proper conduct of the work between the three of us concerned it was agreed that this application also should be prosecuted.

Mr. HUGHES. If the court please, I move that answer be stricken out. The first part of the answer is obviously correct; but what Dr. Dellinger says, he does not recall speaking to Mr. Dunmore about

the A. C. current. The rest is too hazy to prove anything and states no fact. At best, it is the conclusion of this witness.

The COURT. If that be so, we can not interpret that. I think the witness is very circumspect apparently in his testimony, and if you object, I think the answer should stand.

Mr. HUGHES. I object to all of the answer; that is, the last part of the answer, after the first clause.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Exception will be noted.

A. (Continued.) There were conversations between members of the section and myself at which Mr. Lowell and Mr. Dunmore were present in reference to the desirability of developing a radio amplifier or receiving set to be operated by 60-cycle alternating current. These conversations took place during the latter part of 1921 and early in 1922. During these conversations the advantages of using alternating current in place of direct current for operating an amplifier or receiving set were discussed and Mr. Lowell and Mr. Dunmore indicated that they were very desirous of being assigned to work on such a development.

Q. Had the Bureau of Standards previous to that done any work in connection with the use of the alternating current in connection with radio?

Mr. HUGHES. I object to that as immaterial.

The COURT. Does that lead up to these gentlemen and their work?

Mr. HOLTZOFF. Yes. I want to show that the radio section of the Bureau of Standards had been interested and had been working on the general application of alternating current to radio.

The COURT. As a part of its general function?

Mr. HOLTZOFF. Yes.

The COURT. Do you object, Mr. Hughes?

Mr. HUGHES. Yes.

The COURT. Objection overruled.

Mr. HUGHES. Exception, please.

The COURT. Let the exception be entered.

A. Yes.

By Mr. HOLTZOFF:

Q. What had the Bureau of Standards done in connection with the application of alternating current to radio?

Mr. HUGHES. I have the same objection and if there is more than one question, perhaps we can let it extend throughout this line.

The COURT. It will be understood that your objections and exceptions to all questions of this character will be entered.

A. About 1919 or 1920 a development had been made by the radio section for the use of alternating current supply instead of batteries for radio-transmitting sets.

Q. Did the Bureau of Standards issue any publication in reference to this matter?

A. Yes.

Q. I show you Scientific Paper No. 381 of the Bureau of Standards, dated June 18, 1920, and I ask you if that is the paper to which you refer.

Mr. HUGHES. If the court please, I object to this because the witness has already testified that this pertains to a radio-transmitting device. That is just as far removed from a radio-receiving device as the East is from the West. There is no connection whatever, and the patents under discussion here have no relation whatever to any patent which would have been taken out on a radio transmitting device using alternating current. It can have no possible connection with this proposition.

The COURT. The substitution of alternating current for storage battery relates to a transmitting apparatus?

Mr. HOLTZOFF. The patent and invention in suit relates to the receiving set. This particular paper relates to the same thing for a transmitter. I do not claim that the two are the same or that the patent has any relation to this particular paper.

The COURT. It defines the scope of the function of the bureau.

Mr. HOLTZOFF. Precisely.

The COURT. I think it is pertinent.

Mr. HUGHES. The Government can not define the scope of the bureau by merely showing what the bureau did. It can define the scope by showing what the law allows it to do.

The COURT. You revert to the original objection?

Mr. HUGHES. Yes. Let us recall that these patents in suit have to do with the elimination of hum among other things. There is no such problem in the transmitting end of the game. The two are entirely distinct and separate things. They are not any more related than a steamboat and the Pennsylvania Railroad. They both have to do with vehicles of transportation, but they have no similarity whatever. The use of alternating current in a transmitting device and the use of alternating current in a receiving device involves an entirely different and disassociated problem of radio engineering.

The COURT. The objection is overruled.

Mr. HUGHES. An exception, please.

The COURT. Entered.

A. Yes.

Mr. HOLTZOFF. I offer the paper in evidence.

Mr. HUGHES. I object to that on the grounds already stated.

The COURT. The paper is admitted.

Mr. HUGHES. Exception.

The COURT. Let the exception be entered.

(Received in evidence and marked "Plaintiff's Exhibit No. 19.")

Q. This paper, Scientific Paper of the Bureau of Standards, No. 381, having to do with an electron tube transmitter of completely modulated waves, is that a patentable device?

A. It was a device which from the viewpoint of us in the laboratory was a new development, and I should think it might therefore be patentable, but I am not clear whether I can answer definitely as to whether it was patentable.

Q. Was it patented?

The COURT. It takes a Patent Office and a good many courts to decide that. Do you think that witness is qualified to answer that?

Mr. HUGHES. There were about 20 minutes taken up in qualification, and I think he ought to be qualified. He can certainly answer the last question.

By Mr. HUGHES:

X Q. Was it patented?

A. To my knowledge it was not.

X Q. Dr. Dellinger, is there any similarity in this device with the inventions in suit here?

A. There are certain similarities.

X Q. What are they?

A. The device is an electron or a vacuum or electron tube transmitter, and therefore uses in its fundamental element the very same device that the receiving set does; that is, an electron tube and the problem was to supply the power in the various circuits of the electron tube, such as the plate and filament circuit, and to do that transformers had to be inserted in the circuits both in the receiver and transmitter.

X Q. Are there any hum eliminators in this device?

A. No.

X Q. And that is the very nub of the invention in the devices in suit?

A. Not of the devices in suit, because I believe that in case of the relay, as in the question of the transmitter, the question of the hum does not come in, but in the case of the tube in the loud-speaker and the receiver the hum elimination is the main feature.

X Q. It is one of the main features?

A. Oh, yes. As I recall these things, they were telephone or telegraph devices. In the case of the receiving set and the loud-speaker they can be used for either telephone or telegraph.

X Q. Was this a telephone or telegraph device?

A. As I recall, a telegraph device.

X Q. And these things are telephone devices?

A. Either telephone or telegraph. In the case of the receiving set and the loud-speaker, they can be used for either telephone or telegraph.

Mr. HOLTZOFF. May I show this exhibit to your honor?

By Mr. HOLTZOFF:

Q. I believe that you testified a few moments ago, Dr. Dellinger, that there were some conversations between Mr. Lowell and Mr. Dunmore and yourself at which they expressed a desire to be assigned to work and develop an alternating-current receiving set?

A. Yes.

Q. What followed that expression of their desire to you?

A. There followed a consideration of the question and assignment of Mr. Lowell to the task as one of his duties, it being understood that he was to work part of the time on this and part of the time on another job.

Q. I show you this paper dated January 9, 1922, and I ask you if you recognize the handwriting on that paper?

A. Yes.

Q. Whose handwriting is it?

A. Mr. Lowell's.

Q. Will you state the occasion at which that paper was written?

A. This was an outline of the proposed work on the two jobs which I had asked Mr. Lowell to prepare at the beginning of definitely localizing his time to these two jobs.

Q. Did Mr. Lowell hand you this memorandum on or about the day of its date?

A. Yes.

Mr. HOLTZOFF. I offer it in evidence.

Mr. HUGHES. No objection.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 20.")

Mr. HOLTZOFF. It is very short and perhaps I might read it into the record. It is dated January 9, 1922, "Work on the high-frequency bridge will be continued. A satisfactory balancing of signals has been obtained and the actual measurement work will be tried to ascertain its accuracy. Some amplifier work has been begun wherein the batteries will be done away with if possible and the 60-cycle power utilized both for filaments and plates."

The WITNESS. The first paragraph of this memorandum refers to the other job that I had reference to. It is the second paragraph that refers to the work on the alternating receiving set. After receiving this memorandum I had a written discussion with Mr. Lowell in reference to its contents. The written discussion is contained in this memorandum that I also have here, addressed to Mr. Lowell, which is dated January 11, 1922. This memorandum was prepared by me, and the initials J. H. D. signed at the end of the memorandum are my initials, in my handwriting, and the memorandum was transmitted by me or sent by me to Mr. Lowell.

Mr. HOLTZOFF. I offer the memorandum in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 21.")

The WITNESS. The major portion of page 2 of the memorandum refers to the alternating current receiving set development. It commences with "Now as to the work on the amplifier."

I have here a memorandum dated January 12, 1922, entitled "Memorandum for Dr. Dellinger" and signed "Respectfully submitted, P. D. Lowell," and I recognize the handwriting on the memorandum and the signature at the end of the memorandum as that of Mr. Lowell's. It was received by me in reply to my memorandum of the previous day just mentioned of January 11th. This was dated January 12th. This memorandum is in answer to the exhibit which has just been marked in evidence "Plaintiff's Exhibit No. 21."

Mr. HOLTZOFF. I offer the memorandum of January 12, 1922, in evidence.

The COURT. Received.

(Received in evidence and marked "Plaintiff's Exhibit No. 22.")

All of the memorandum following the point at page 3, beginning "Regarding the amplifier work," relates to the alternating current receiving set.

I have another paper here which has the initials P. D. L. in the upper left-hand corner and the initials J. H. D. in the lower right-hand corner, which is in my handwriting, and in addition some pencil notes which I believe are in Mr. Lowell's handwriting.

It was written shortly after this last memorandum, which I think was January 12th. I notice that it has a questioned date of January 13th and I know it was written at about that time. I caused this memorandum to be transmitted to Mr. Lowell.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. Admitted without objection.

(Received in evidence and marked "Plaintiff's Exhibit No. 23.")

After this exchange of memoranda I do not remember whether there were any interchanges after this point that could be considered definitely of the nature of instructions in reference to proceeding

with work on the radio amplifier or receiving set to be operated by alternating current. I remember seeing him and the apparatus from time to time to see how the work was going, but as I say, I simply can not remember more definitely than that.

Q. Are there papers in the files which would refresh your recollection on this subject?

A. There are several memoranda which you last introduced as exhibits which cover the very point as to division of Mr. Lowell's time between the bridge and the amplifier work.

Mr. HUGHES. I object. There is nothing upon which that is predicated now, if the court please.

Q. I show you a memorandum of January 14th——

The COURT. Do you object to that last answer?

Mr. HUGHES. He is answering something to which there is nothing to reply. My objection to the question was sustained. The witness proceeds to answer with no question before him.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Exception noted.

Q. I show you a memorandum of January 14th, signed by J. L. Preston and addressed to you, and I ask you if that refreshes your recollection as to the instructions which you may have given to Mr. Lowell?

Mr. HUGHES. Before he reads it, if the court please, I object to that. We do not know who Mr. Preston is, where he comes from, and how he figures into the picture at all.

Mr. HOLTZOFF. I shall be glad to show you, Mr. Hughes, if you wish.

The COURT. Have you identified this paper handed to the witness?

Mr. HOLTZOFF. No; I was just about to proceed to do so.

Q. Who is J. L. Preston, whose name is signed to this memorandum?

A. I am a little confused. I did not answer the previous question. Do you wish me to answer this question now?

Q. Answer the previous question first.

The COURT. Do you know what it was?

A. It was—"Does this paper refresh your recollection" as to a division of Mr. Lowell's time?

The COURT. You may answer that question.

The WITNESS. In a way it does refresh my memory, but I find that was not necessary because I had already that clearly in mind; that there was a division of time specified.

Q. And how was it specified?

A. In the memoranda; one or two of those previous memoranda.

Mr. J. L. Preston is a man who was a member of the radio section at the time in question and was one of the group chiefs, and in addition was an administration assistant in respect of certain matters in the management of the section.

My office was in room 205, which was 2 or 3 doors from rooms 203 and 204, which were the rooms in which Mr. Lowell was working. From time to time I had occasion to look into these rooms where Mr. Lowell was working on the radio receiving set operated by alternating current.

I stopped in to examine the development and listened in on the signals produced with a view to seeing what success was being obtained in the major project of the elimination of the hum. This was about during the first 4 months of 1922. It is impossible for me to recall how frequently I had occasion to inspect the work but it is my recollection that it was something of the order of three or four occasions during that period.

I recall that during this time Mr. Lowell was also working on a loud-speaker to be operated in the same manner as the radio receiving set and that we had some discussions of this, but whether I actually saw and listened to the performance of the loud-speaker I could not testify, because my recollection is not sufficiently definite on that point.

The discussions between Mr. Lowell and myself as to the work on the loud-speaker were to the effect that such a development will be a desirable addition and a very proper part of the work and I approved of his doing it.

I have a set of cards headed "F. W. Dunmore," each containing a series of 6 entries for different dates, or most of them containing a series of 6 entries, which are the weekly report cards written by Mr. Dunmore in the course of his work over a certain period, which are in his handwriting. These cards are a part of the files of my section, and were known as Mr. Dunmore's weekly report cards. They are the weekly report cards to which I referred earlier in my testimony, which every member of my staff was required to keep and turn in to the office.

Mr. HOLTZOFF. I offer in evidence the weekly report cards of F. W. Dunmore, the first card covering the week from April 4 to April 9, 1921, and the remaining cards covering the period commencing August 1, 1921, and ending August 5, 1922.

The COURT. Admitted without objection.

(Cards received in evidence and marked "Plaintiff's Exhibit No. 24.")

Mr. HOLTZOFF. I thought perhaps it might be helpful if I called your attention to certain specific entries and they could be noted in

the record. It would not take but a few minutes and it would delineate the story before you. I want to call your honor's attention to the entry on the first card, April 8, 1921:

"Talked with Captain Vaughan of Dayton regarding the aerial navigation program."

Now, I wish to call your honor's attention to the entry for August 11th, that will be the third card:

"Read dope on remote control via radio secret systems, etc."

Now, the next card, the entry for August 15th:

"Worked on set-up for recording signals."

August 16th:

"Worked on recorder problem, tried various coils, B battery potential, etc., to get set to work."

August 17th:

"Worked on recorder problem."

August 18th:

"Set up new recorder circuit with amplifier."

August 19th:

"Work found needed more negative C battery to make recorder tube critical at oscillating point."

August 20:

"Collected data on Tulip's calibrations (R. C.) and put same in tabular form for comparison."

On the next card, August 23:

"Worked on electron tube relay circuit."

August 24:

"Worked on electron relay recorder."

Then, if your honor will take the entry for September 6th:

"Worked on tube relay circuit. Got relay to operate on signals, that gave 0 to 20 milliamps deflection."

September 7:

"Went to N. Y. and attended I. R. E. meeting on Hoxie recorder"—the handwriting is not clear.

And, then, if your honor will pass to the next card, September 10.

"Worked on recorder getting audio howl out of it. Set out loop circuit for receiving undamped with detector and 2 audio stages, tried audio tuning on audio stages."

September 11:

"Worked on recorder. Put grid leak across secondary of input transformer to stop howling."

Then, the entry September 12:

"Worked on recorder, O. K. on shaking machine."

And, then, if you honor will pass on to the next card, September 13th:

"Looked up dope on recorders in the library."

September 15:

"Worked on radio recorder."

September 16:

"Worked on recorder, got 0 to 40 milliamps changed for moderate strength signal. Visited Naval Observatory and found them using recorder like mine."

September 17:

"Connected recorders to antenna and got NAH and NAI and NSO to operate it and wrote letters."

September 19:

"Rewound relay to 12,000 turns. No. 28 SS enamel, 1,400 ohms."

September 20:

"Adjusted recorder, using outside signals and experimenting on new relay. Read dope on recorders."

"Wound loop for picture to show sample loop."

September 22:

"Got apparatus set up and had picture taken of sample loop and set, got up apparatus to get sign for case on recorder; designed same."

September 23:

"Worked on relay circuit, got loop and apparatus hooked up to make wave length turn data."

September 24:

"Assembled recorder on base and wired same up and got it to operating satisfactorily."

The next in there is September 26:

"Went down to Northland and had picture taken of sample D. F. and operator. Worked on relay. Found that weight on armature stopped static from working out."

September 27:

"Worked on relay mounting same on base. Made up variable tap C battery."

September 28:

"Mounted relay on base and put in transformer to operate filament on alternating current. Worked O. K."

September 29:

"Worked on relay, fixed same up with plug, etc., to operate by plugging into any plug of receiving set."

And there is nothing on September 30 on that.

October 3:

"Worked on recorder circuit."

October 4:

"Lowell and I worked on recorder circuit and he got stunt of audio tuning section of transformer. I tried tuning relay coil, but did not have enough C. He tried with more C and worked fine. Works on rather weak signals now with right audio note."

October 5, he says:

"Experimented with recorder; can tune to audio note fine and eliminate QRM; got Bordeaux O. K."

October 6:

"Worked with recorder and wound 240 turns of 4-foot coil and measured its wave length with different circuits, showed Eckhardt the recorder."

Mr. HOLTZOFF. Did you know who Eckhardt was, Dr. Dellinger?

The WITNESS. Yes; he was chief of the sound section of the bureau at one time, and I think was at this particular time. At any rate, he was a bureau employee and he had worked on similar recorder problems.

(Reading of cards continued by Mr. Holtzoff.)

October 17:

"Started report on a relay for remote control by radio."

October 18:

"Worked on report of relay for remote control by radio."

October 20:

"Determined speed of operation of recorder."

October 21:

"Worked on report of recorder. Made some tests on the same, talked with Mr. W. D. Laughlin, D. F. man from navy yard, Philadelphia."

Mr. HOLTZOFF. What is the meaning of the abbrevation "D. F." in this connection?

The WITNESS. Direction finder.

By Mr. HOLTZOFF:

Q. Was that another project that Mr. Dunmore was working on at the time?

A. Work on direction finders was one of the Air Service conditions that was studied out.

(Reading of cards continued by Mr. Holtzoff.)

"October 22. Worked on recorder report. Designed panel to hold recorder apparatus. Tried out further audio tuning tests on recorder.

"October 24. Went down to Signal Corps to see Bruce relay in operation. Went over picture proofs of D. F. paper. Worked on design of recorder panel.

"Oct. 25. Worked on design of recorder panel. Gave talk on recorder.

"Oct. 26. Attended group chief's meeting. Made comparison of Federal and 621 audio transformer in recorder.

"Oct. 27. Worked on recorder report.

"Oct. 28. Talked with Dr. Miller regarding recorder."

The WITNESS. I presume this entry refers to Dr. J. M. Miller, who was a member of the bureau engaged in radio work at one time, but I believe was at this time an employee of the Naval Research Laboratory, having left the bureau to go there.

The Naval Research Laboratory is now located at Anacostia, in the southern part of Washington, and at that time I think it was also located there. The Navy Department did have a research laboratory located in the lower floor of the Bureau of Standards, which for a number of years was their principal research laboratory in Washington, and then subsequently the laboratory at Anacostia, to which I refer, was established and was a much larger laboratory, and for several years this additional laboratory was also maintained by the bureau. You might be referring to the one at the bureau or the other one.

(Reading of cards continued by Mr. Holtzoff:)

"Nov. 1. Finished report on radio receiving relay.

"Nov. 22. Worked with Engel wiring up recorder. Got it finished and took it down in Navy Laboratory and hooked it on to a printing telegraph and NSF wrote to us by radio. Worked great."

The WITNESS. Mr. Engel was a member of the radio section. The letters NSF are the call letters of a Navy transmitting station which was located at Anacostia, D. C.

(Reading of cards continued by Mr. Holtzoff:)

"Nov. 23. Worked recorder again for further demonstration of the radio typewriter before Navy officials.

"Nov. 26. Read recorder dope in Wireless World. Put transformer on recorder so as to light filaments from 60 cycles. Also did other work on it. Went over report of radio phone tests for Associated Press.

"Nov. 28. Connected up 250 to 7,000 meter tuner and recorder and tried out combination. Found I could get best recording with set oscillating. Made plug leads, etc., for use with recorder.

"Nov. 29. Worked on radio phone, Coast Guard report, and relay recorder.

"Dec. 2. Tried 150 D. C. generator on recorder as plate voltage. Had smoothing out inductance and capacity. Found it worked O. K. Talked with Duncan regarding use of rectifier tubes to get plate voltage for recorder."

The WITNESS. Mr. Duncan was a man who had been a member of our radio section and who left us to join the Signal Corps, and I believe was at this time working in the Signal Corps Laboratory, which was also located in our building on the floor below our laboratory.

(Reading of cards continued by Mr. Holtzoff:)

"Dec. 5. Went down to Air Service patent section regarding patent on receiving relay.

"Dec. 6. Wrote up dope re patent on relay. Set up audio amplifier with tuned audio stages. Got very good selectivity. Put condenser on permanent set-up to tune it to the audio note of recorder.

"Dec. 7. Tried method of getting plate voltage for receiving from 60-cycle alternating current. Could use a synchronous motor and charge condenser on the positive humps of alternating current wave by a contactor on wheel and thus charge condenser.

"Then there is a diagram opposite this entry."

The WITNESS. The meaning of this diagram opposite the entry of December 7 appears to represent a means of converting alternating current into the direct current for the purpose of supplying one of the voltages necessary for the recorder by inserting a device called a rotating commutator, which turns around each successive half cycle of the alternations so that the alternations become currents in one direction. This enables the apparatus to be operated by alternating current.

(Reading of cards continued by Mr. Holtzoff:)

"Dec. 8. Set up a receiving tube double-wave rectifier to get 200 volts direct current from 60-cycle 110 volts alternating current. Used this circuit and it worked fine on six-tube amplifier as plate voltage. Worked recorder fine or with a resistance across output to make voltage drop to 80 volts. It worked on six-tube amplifier fine."

The WITNESS. The significance of the diagram opposite to the entry of December 8th represents a method of securing direct current to operate one of the circuits of the amplifier from an alternating current supply by introducing two of what are called tube rectifiers; that is, two vacuum tubes of a certain type, the function of which is to cut off all the current flowing in one direction and by using one of those which lets current through in the one direction to operate on half of the cycles in a certain direction, and the other to operate on the alternate cycles, and connecting them in such a way that with the two feeding together you thus have succeeded in converting all of these successive alternations of the current into current of one direction. Such a conversion of current is required in order to operate the apparatus.

The COURT. Does that cut out the hum?

A. I believe the question of hum does not come into this apparatus as this relay is something to which one does not listen and, therefore, would not be disturbed by hum. The electrical fluctuations which cause the hum might perhaps interfere with the operation of the relay, but the hum itself would not come into the case.

(Reading of cards continued by Mr. Holtzoff:)

"Dec. 9. Set up a double-wave tungar rectified with big smoothing resistance and got direct current to light filament tubes from alternating current. See notebook. Made phone tests with P. O. Department."

The WITNESS. The term "tungar rectifier" means a vacuum tube device the same in principle with the vacuum tubes last referred to, but a larger tube and especially designed to carry heavy currents and usually used for the charging of batteries.

(Reading of cards continued by Mr. Holtzoff:)

"Dec. 10. Made up list of proposed work. Set up a detector and two stages of audio with filaments on alternating current. Wired stabilizers with center taps going to grids. Also used C battery. Got rid of most of hum.

"Dec. 12. Spent all morning on recorder patent with Mr. Press, of Air Service.

"Dec. 13. Worked on alternating-current transformer to give both filament and plate current supply to operate tubes in recorder.

"Dec. 15. Worked on transformer to give 3, 6 volts alternating current supply circuits from 110 alternating current and one 300 volt and one 70 volt. This was finished and connected up to recorder and it worked O. K., using the rectified alternating current for plate voltage and the alternating current on tube filaments. Made radiophone test with P. O. and talked about it with Edgerton."

The WITNESS. Mr. Edgerton was a man who was in charge of radio work of the Post Office Department.

(Reading of cards continued:)

"Dec. 16. Succeeded in getting the C battery voltage for the grid from the alternating-current line, so that the A, B, and C battery power are now obtained from the alternating-current line.

"Dec. 19. Got equipment together for a new recorder to be worked entirely from the alternating-current line. Started layout of new recorder.

"Dec. 21. Made tests on recorder, using new tape registering device. Succeeded in recording messages from POZ. Cleaned up room 203. Started revise report on recorder."

The WITNESS. I think POZ were the call letters of a station of Germany.

(Reading of cards continued:)

"Dec. 22. Finished revision of recorder and drew up a new circuit program for same and started tracing it.

"Dec. 23. Finished tracing above diagram and traced three others to send away with recorder report for publication of same.

"Dec. 24. Got recorder report ready for publication in the Journal of the A. I. E. E. Worked on layout of apparatus for new recorder."

The WITNESS. The A. I. E. E. was the American Institute of Electrical Engineers.

(Reading of cards continued:)

"Dec. 27. Worked on layout of new recorder.

"Dec. 28. Fixed old recorder up with the new tape register for demonstration use, including the dry cell for operating the register within the recorder.

"Dec. 29. Worked on new recorder.

"Dec. 30. Continued work on recorder. Read radio magazines. Got report on recorder through finally into the outgoing mail.

"Dec. 31. Experimented with a high-speed type of relay for use with recorder."

We now come to 1922:

"Jan. 3. Completed layout of panel for type B recorder and got work started on same in shop.

"Jan. 4. Had new drawing made of recorder circuit and for supports for apparatus in new recorder.

"Jan. 5. Got new mechanic started on recorder. Worked recorder on POZ at 30 words per minute.

"Made satisfactory tests with it on radio control at 40 words per minute.

"Jan. 6. Tried out limiting effect of a tube with low-filament current. Studied Weinberg's paper on recorders.

"Jan. 7. Checked up quotations on relay, and mechanic's work on recorder in shop. Wrote letter to Vaughan, describing selective receiving stunt, using three or more transmitters operated by same key on different lengths, and three or more receivers, each tuned to the different wave lengths and three or more recorders each on a receiver, the three or more recorder relay contacts being in series; that is, three or more wave lengths must be received at once."

The WITNESS. That entry refers to the sort of an experiment having in view the overcoming of interference by having a number of transmitters each operating on a different wave length and then receiving sets corresponding to them and tuned to them, each operating a recorder, the idea being that it would be unlikely that interference would simultaneously disturb all three of them. I am not clear at a hurried glance that that is the whole story. It may be that there was another application in view there such as secret signalling such that an enemy listening to such transmission would not be able

to receive the signal unless he had a similar complicated set of a multiplicity of receivers.

(Reading of cards continued:)

"Jan. 9. Checked up pictures, prints, etc., for Coast Guard and recorder reports. Got wire in shape together for recorder.

"Jan. 10. Made up a set of seven 0.00025 m. f. fixed condensers (compact type) for the audio tuning in the type B recorder.

"Jan. 11. Worked on construction of type B recorder. Made up a transformer to give filament current plate voltage and grid voltage from the 60-cycle line.

"Jan. 12. Set up new transformer and tested same out before putting on last two coils. I got drop of 30 volts in plate circuit when signal came in. This is not objectionable. Talked with Captain Walton, of Coast Guard, regarding radiotelephony.

"Jan. 13. Made out proposed schedule of work for Air Service. Drew up brackets, etc., for mechanic—brackets needed for mounting apparatus contained in type B recorder.

"Jan. 16. Made up further list of proposed work on Air Service project.

"Jan. 17. Mounted Rubbell plug on recorder and cut hole in box so as to plug 110 A. C. on recorder. Also mounted six binding posts so that if necessary recorder may be used on battery supply A, B, and C.

"Jan. 18. Gave mechanic instructions on making up supports for apparatus in type B recorder. Started winding on new relay.

"Jan. 19. Wound Morkrum type B–1 relay with 16,000 turns of No. 38. Connected it into recorder circuit and made a few tests.

"Jan. 20. Made comparison tests on Morkrum relay and the ordinary relay as now used on recorder. The Morkrum relay is superior to some extent due to the better mechanical construction but was not very much more sensitive. Went over in machine shop and followed up work on type B recorder."

The WITNESS. I do not know the Morkrum relay to which these entries refer; Morkrum is a trade name.

(Reading of cards continued:)

"Jan. 21. Tried out new relay on speed work. It operated at 50 words per minute O. K. Also got an idea for transmitting three or more messages on one wave length by using type A or B recorder. See notebook for details.

"Jan. 23. Worked with mechanic on relay. Set up two choppers in parallel and sent two messages on different audio notes."

The WITNESS. We have mechanics employed in the bureau, and their duties are to construct apparatus as required in the course of the bureau's technical work. They work in conjunction with the

technical men in the sense that they perform construction work specified by them.

(Reading of cards continued:)

"Jan. 25. Received new Bunnell relay. Rewound same with 22,000 turns of No. 38, and made test. It is somewhat more sensitive on weak signals than the one now used and has much more pep on with the average signal strength.

"Jan. 26. Worked with mechanic putting finishing touches on type relay. Made layout for new Bunnell relay on same. Worked on two-note audio-frequency tube generator for duplex radiotelegraphy.

"Jan. 27. Worked on duplex receiving set and sending circuit. Connected two audio tube generators to input of radiophone and modulated radio wave at two audio notes. Received these on one length and made either work a relay at will through the tuned recorder circuit. Worked it same as though I had two relay recorders each working on a different note and receiving its respective message.

"Jan. 28. Worked on type B recorder, wiring up same.

"Jan. 30. Worked all day wiring up type B recorder. Talked with Lowell regarding alternating-current receiver.

"Jan. 31. Worked all day wiring up type B recorder.

"Feb. 1. Completed wiring of recorder but found I had a poor tube socket, so changed it. Made test on recorder and it worked fine. Works entirely on A. C. Adjusted a buzzer to give good note. It also operates on A. C. It made type B recorder register one signal on tape and the type A another, both at same time, and with set tuned to one length but got two stations each on a different note.

"Feb. 2. Cleaned up room 203. Demonstrated new recorder to Crocker."

The WITNESS. I do not know who Crocker was.

(Reading of cards continued by Mr. Holtzoff:)

"Had more reports on it ordered. Worked two recorders at once on NSS, one recorded his spacer wave and the other the sending wave.

"Feb. 3. Tested out new recorder to see if it operated on batteries O. K., and it did. Had a cover for same drawn up. Talked with Lowell regarding design of new A. C. receiving set and amplifier.

"Feb. 4. Took recorder equipment to 3XF."

The WITNESS. 3XF was the call signal of a station.

(Reading of cards continued:)

"And tried to receive two messages from WWV on same antenna. Worked WWV phone set and modulated it with two audio notes.

Was able to record a few letters simultaneously on note, other"—the rest of that does not seem to be very legible on the copy I have.

"Feb. 6. Gave Navy demonstration of type A and B recorder as they have asked officially to submit a report on it.

"Feb. 15. Put new B batteries on type A recorder and fixed fine C voltage adjustment. Got apparatus together for phone set for director."

(Reading of cards continued:)

"Feb. 16. Got tape record of NSS——"

By Mr. HOLTZOFF:

That apparently is a reference to the fact that they were using the relay recorders to operate an apparatus for recording the message on tape.

(Reading of cards continued by Mr. Holtzoff:)

"and his spacer wave by the use of type A and B recorder. Wrote up an idea of remote control by radio, using 2 crossed coils on slightly different wave lengths and getting 2 audio heterodyne notes, each of which work a relay, the relay coil of each recorder operating on a single armature so if a signal intensity from two coils is equal, the arm is pulled equally in both directions and doesn't move. If one gets a stronger signal than other, it goes to right or left, and so may work recorder to right or left.

"Feb. 17. Got recorder in shape and took it down to A. R. R. L. convention. Attended talks and gave one.

"Feb. 18. Wrote up another idea of a direct-reading self-reading D. F.

"March 4. Wired up Magnavox and mounted same on base with three switches for throwing either to phones or Magnavox. Also for throwing from antenna to loop and a filament switch."

The WITNESS. The meaning of the term "Magnavox" is that it is a trade name of a type of loudspeaker.

(Reading of cards continued:)

"March 8. Proofread abstract of my recorder paper and P D L—A C amplifier."

The WITNESS. "P D L" refers to Percival D. Lowell.

(Reading of cards continued:)

"Witnessed competitive test by Navy of my relay and Bruce relay. Doped out tube circuits to try 100-meter coil aerial, and will try them when weather gets warmer.

"March 17. Got both recorders working O. K. and made demonstration to visitors.

"March 20. Wrote up abstract of recorder report for Radio Service Bulletin.

"April 3. Spent the morning working on the permanent set-up relay recorders as they were not working properly.

"April 11. Put strap on type B recorder. Got mechanic going on tube sockets for short-wave work.

"April 12. Put strap on type A recorder. * * * Worked on working drawings of recorder with Buckley."

The WITNESS. Mr. Buckley was the draftsman of the radio section. His function was to prepare drawings of devices prepared in the radio section, sometimes with a view to their being made in the shop and sometimes with a view to the drawings being included in reports or publications. In making these drawings he worked under the instruction of the technical men of the staff.

(Reading of cards continued:)

"April 14. Worked on recorder detailed drawings.

"April 15. Worked on recorder drawing.

"April 17 to 19. Went to Chicago to present paper on relay recorder before the convention of the A. I. E. E."

The WITNESS. These abbreviations stand for the American Institute of Electrical Engineers.

(Reading of cards continued:)

"April 27. Went over recorder working drawings and made additions.

"May 1. Worked on recorder drawings.

"May 2. Worked on recorder drawings.

"May 3. Tested out cloth loop on alternating-current receiver. Tested out recorder 110-volt transformer which Baer has completed."

The WITNESS. Mr. Baer was a technical assistant in the radio section.

(Reading of cards continued:)

"May 4. Got Signal Corps started on making 2 type B recorders. Got pictures together for recorder article in R News."

The WITNESS. R News stands for Radio News, a radio magazine.

(Reading of cards continued:)

"May 6. Got material together for two recorders for Signal Corps.

"May 11. Started making up an amplifier with one stage R F amplification."

The WITNESS. R F means radio frequency.

(Reading of cards continued:)

"May 24. Wound relay magnet coils. Revised drawings of recorder and got Diaz started on them.

"May 25. Worked on 2 type B recorders for Signal Corps.

"May 26. Worked wiring up the 2 type B recorders for Signal Corps.

"May 27. Continued work on recorders.

"May 29. Worked all day wiring up 2 type B recorders for Signal Corps.

"May 31. Finished one recorder and tested it out and got it working O. K. Found one lead wrong and a broken-down paper condenser.

"June 1. Worked on second type B recorder for Signal Corps.

"June 2. Finished relays and tested them and delivered them to Signal Corps.

"June 6. Proof read Lowell's radio frequency amplifier and alternating-current amplifier paper.

"June 7. Went over completed recorder drawings and made several corrections and additions. Measured relay transformer voltage for data to go on relay drawings.

"June 12. Worked with relay for Signal Corps and got some tape on Fort Wood, using detector and two stages audio." The handwriting seems illegible.

"June 14. Checked over recorder drawings. Demonstrated recorder records to Col. Mauborgne.

"June 15. Went downtown to Signal Corps office and got relay type B working."

The WITNESS. I know the Col. Mauborgne referred to in this entry. He is an officer of the Signal Corps of the Army.

(Reading of cards continued:)

"July 25. Went over recorder drawings with J. L. P. and told Buckley what changes to make."

The WITNESS. J. L. P. refers to J. L. Preston, a member of the radio section. He was a group chief and was an administrative assistant in charge of such matters as equipment.

I recognize this batch of cards as being the weekly report cards of P. D. Lowell. They are in his handwriting. They were filed in my office and they are the weekly report cards which I have heretofore referred to in my testimony which were required to be kept by Mr. Lowell as a member of my staff.

Mr. HOLTZOFF. I offer in evidence the weekly report cards of P. D. Lowell for the period commencing August 1, 1921, and ending July 15, 1922.

The COURT. Admitted without objection.

(Received in evidence and marked "Plaintiff's Exhibit No. 25.")

(Reading of entries on cards of P. D. Lowell by Mr. Holtzoff:)

"January 10, 1922. Set up amplifier circuit 1 R F tube detector and 1 A F to work filaments on 60-cycle supply."

The WITNESS. 1 R F is a part of the phrase "1 R F tube," meaning a single electron tube used as a radio-frequency amplifying stage; in other words, only one stage of radio amplification. 1 A F means that one tube is used as a single stage of audio-frequency amplification.

(Reading of cards continued:)

"Found that hum could be reduced materially by connecting grid circuits to voltage dividers across filament supply voltage. Used batteries for plate voltage.

"Jan. 11. Tried 2 radio-frequency stages and crystal detector. Worked much better with crystal detector than with tube detector. Various circuits tried to reduce the hum when using tube detector. Little success, however.

"Jan. 12. Wrote outline for Dr. Dellinger. Tried more circuits with tube detector on alternating current, 60 cycles, but with no further improvement.

"Jan. 13. Tried 3 radio-frequency stages, crystal detector, and alternating current on filaments and rectified alternating current on plates. Used Moorehead tube to rectify 80 volts alternating current for plates. This source of plate voltages seems fairly satisfactory, but quite a hum due to alternating current on filament circuit.

"Jan. 16. More work on amplifier using 60-cycle alternating current on filaments and plates. Mr. Dunmore cooperated. Found that when 60-cycle hum is balanced on grid circuit that there is a small 120-cycle hum left due to change in plate current when filament temperature changes. Can not balance it out.

"Jan. 17. Found radio-frequency amplification increased and hum decreased by introducing a 0.02 microfarad condenser in series with radio frequency grids. This must allow the grids to assume a more favorable voltage for amplifying. Tried one radio-frequency stage, crystal detector, and one audio-frequency stage. A 0.02 microfarad condenser shunted by 80,000 ohms in audio-frequency plate helped cut down hum.

"Jan. 18. Tried more tests to use tube detector but with poor results. Set up tungar rectifier for filament current supply.

"Jan. 19. Rectified alternating current on filaments is N. G. due to unsymmetrical form of direct current. Can not smooth it out sufficiently and can not balance out hum in grid circuit.

"Jan. 20. Back to pure alternating current on filaments. Works better. Set up two radio-frequency stages, crystal detector, and 2 audio-frequency stages, quite hummy but much improved with 0.02 condensers in grids and plates. Rectified alternating current used on plates.

"Jan. 21. Assisted Mr. Dunmore on some experiments with his recorder."

The Witness. It was customary for the various members of the laboratory staff to cooperate with one another on their tasks.

(Reading of cards continued:)

"Jan. 23. FWD and I set up Magnavox to work on 110 volts 60-cycle alternating current in conjunction with alternating current operated amplifier.

"Jan. 24. Got Magnavox working on 60-cycle alternating current, using tungar for rectifying alternating current for field coil. Connected it to the alternating-current operated radio-frequency and audio-frequency amplifier and got very good results throughout, only slight hum present. Helped Dunmore on recorder tests.

"Jan. 25. Tried C battery in grids of amplifiers and found improvement in the elimination of the hum as well as in amplification and stability of operation.

"Jan. 26. Made some practical tests with alternating-current operated amplifier and Magnavox. Speech from several stations reproduced very nicely. Recommend 2 sets to be made up in shop, one radio-frequency, audio-frequency amplifier and one Magnavox set for laboratory use.

"Jan. 27. Tried tube detector again but got no encouraging results.

"Jan. 28. Helped Dunmore on some recorder tests.

"Jan. 30. Started design of 5-tube alternating-current amplifier.

"Jan. 31. Started shop drawings for the same.

"Feb. 1. Worked on shop drawings for the same.

"Feb. 2. Mr. Buckley took over drawing and design of alternating-current amplifier. Conferred with him on same.

"Feb. 3. Conferred with Mr. Buckley re alternating-current amplifier design. Made some practical tests with alternating-current amplifier. Conferred with Dr. Brooks re transformer design."

The WITNESS. Dr. Brooks was the chief of the section of the electrical division devoted to electrical instruments.

Q. Did questions of transformer design come within the purview of his duties?

A. That section had among its duties testing of transformers of various kinds and I should say that a transformer design was an incidental matter to which it would naturally give attention.

Mr. HUGHES. I move to strike it out, if the court please. The witness can testify what the section did properly, but I object to testimony as to what its duties were, because that is a conclusion of law, the construction of which this witness is not qualified to give.

The COURT. Objection is overruled.

Mr. HUGHES. Exception, please.

The COURT. Let an exception be entered.

(Reading of cards continued:)

"Feb. 4. Worked with Mr. Buckley on amplifier design details. Worked on job of proper rectified alternating-current supply for Magnavox field coil.

"Feb. 6. Conferred with Buckley re drawings for alternating-current amplifier. Assisted Mr. Dunmore on some recorder tests.

"Feb. 8. Trying to get best alternating-current voltage on tungar plate to give prompt direct-current voltage on Magnavox field coil. Talked with Sanford, magnetic section on proper design for power transformer.

"Feb. 9. Made up alternating-current power transformer with 5 windings for use with alternating-current amplifier and Magnavox.

"Feb. 10. Started design for complete rectifier units to go with alternating-current amplifier.

"Feb. 11. Tried some speech amplification, using 2 audio-frequency stages and Magnavox, all on alternating current. Some distortion due to sharply tuned audio-frequency transformer. Modulation transformers worked better. Amplification is very good with very little alternating-current hum.

"Feb. 13. Wrote report on alternating-current operated amplifier for publication. Tried resistance coupled audio-frequency stages in alternating-current amplifier. Better for speech amplification but not so much amplification per stage as transformers.

"Feb. 14. Worked on shop drawings for rectifier unit for alternating-current amplifier.

"Feb. 16. Conferred R. S. O. re publication alternating-current amplifier unit."

The WITNESS. R. S. O. refers to R. S. Ould, a member of the radio section.

(Reading of cards continued:)

"Rewound filament transformer windings for alternating-current power transformer. Investigated catalogues and ordered some apparatus.

"Feb. 17. Worked on shop drawings for rectifier unit.

"Feb. 18. Tried modulation transformers in audio-frequency stages of alternating-current amplifier. Better for radio phone speech and music but not as much amplification per stage as audio-frequency transformers. Tried choke coils in series with plate-voltage supply to smooth out rectified plate current. Helped some to reduce hum.

"Feb. 20. Started construction on alternating-current amplifier in shop. Got all parts together, cut and drilled bakelite panel about 5 hours in the shop.

"Feb. 21. In shop on amplifier about six hours fitting bakelite shelf.

"Feb. 23. In shop on amplifier about 6 hours, making battery cases and other small parts.

"Feb. 24. In shop on amplifier about 6 hours. Mounting transformers and other pieces.

"Feb. 25. In shop on amplifier about 4 hours. Assembling and fitting parts. Made up a new telephone transformer.

"Feb. 27 to March 4. Worked entire week on finishing machine work, assembling of parts, wiring and testing alternating-current amplifier units, having some trouble in making it work properly, rectifier unit is still unmade.

"March 6. Worked on alternating-current amplifier, trying to make it function properly.

"March 7. Found plate rectifier not operated properly and fixed it. Put additional choke coil in rectifier circuit. Worked more on alternating-current amplifier. Found method of limiting direct-current voltage output regardless of rectifier filament.

"March 9. Continued test to improve operation of alternating-current amplifier.

"March 10. Ditto. Also took some turns off filament windings of power transformer.

"March 11. Continued tests to improve operation on alternating-current amplifier. Started report on radio-frequency amplification.

"March 13. Wrote on radio-frequency amplifier report.

"March 14. Made some changes in alternating-current amplifier. Put one microfarad condenser from detector to filament. Helped to reduce the hum. Found that a choke in rectifier circuit helped some. Thus with this choke in it was found that the smoothing out condensers could be reduced to 2 microfarads."

The WITNESS. The diagram opposite the entry just read is a diagram that illustrates that entry. The diagram shows that in the output circuit of a rectifier tube two condensers are shunted across the output and that the choke coil referred to is connected in series between the junction points on one side of the circuit and the 2 condensers.

(Reading of cards continued:)

"March 15. Further tests with A. C. amplifiers.

"March 16. Further tests with A. C. amplifiers. Trying to improve operation.

"March 17. Further tests with A. C. amplifiers. Trying to improve operation.

"March 18. Making plans for assembly of rectifier unit for A. C. amplifier.

"March 20. More tests with A. C. amplifier. Ground connection on filaments helps reduce hum.

"March 21. Trying to make over a telephone receiver to serve as a good loud-speaking reproducer.

"March 22. Ditto. Spacing diaphragm farther from poles and ear cap farther from diaphragms allowed good reproduction without distortion. Used with large horn.

"March 23. Rewound receiver coils with 40 turns and used with step-down transformer to supply current. Worked about same as with high-value winding.

"March 24. Tried increasing magnetism of pole of magnets by winding a magnetizing coil on it, current from battery. Increasing magnetization no better. Diaphragm probably saturated.

"March 25. Heavier diaphragm not better. Tried 2 tubes to rectify plate voltage, using both sides of A. C. cycle. Somewhat better results, but not much.

"March 27. Worked on drawing for rectifier unit to go with A. C. amplifier.

"March 28. Made temporary mounting for rectifier unit to take home for test.

"March 29. Worked on drawings for rectifier unit. Helped Dunmore on receiving end of 100-meter transmitter.

"March 30. Made tests with detector tube, filament on A. C. Single detector is good but when audio is added hum is too great. Demonstrated possibility of balancing out hum with double-tube circuit."

By Mr. HOLTZOFF:

Q. Will you look at the diagram opposite the entry which I have just read and explain that diagram?

By Mr. HUGHES:

Q. When did you first see the diagram, Dr. Dellinger?

A. I don't know whether I have seen it before the present moment or not.

Mr. HUGHES. I object to his answering the question, if the court please. He does not show anything in connection with the time the diagram was made or shortly thereafter. He is asked after eight years to explain the diagram, and after a great many things have happened in between. He has no common-sense knowledge of that paper. He has no knowledge referring to the time that the diagram was made.

The COURT. The objection is overruled.

Mr. HUGHES. Exception, please.

The COURT. An exception will be noted.

The WITNESS. The diagram shows an arrangement of two electron tubes with their outputs connected to a transformer, and in turn a telephone receiver connected to the output of that transformer, the transformer being a device split into two parts in such a way that the rectified parts of the alternating current coming into each of the tubes will produce an effect in the output circuit of the transformer and hence in the telephones, thus securing output current in both

halves of the cycle of any alternating component of the current that would enter the tubes, whereas if there were only one tube present such components would be present in the output only during half of the cycle.

By the COURT:

Q. It illustrates the entry under what date?

A. It illustrates the last sentence of the entry under March 30th.

(Reading of cards continued by Mr. Holtzoff:)

"April 1. Worked on drawings for rectifier unit.

"April 3. Finished drawings for rectifier unit. Started construction of rectifier unit in shop.

"April 4. Worked on rectifier unit in shop." There is the same entry on the 5th and 6th. We have also on the 6th, "Rewriting report on radio frequency amplifiers."

"April 7. Worked on R. F. amplifier report. In shop on rectifier construction.

"April 8. Worked on R. F. amplifier report. Finished rectifier. Started carpenter on making wood cases for A. C. amplifier and rectifier.

"April 10. Worked on R. F. amplifier report. Worked on rectifier unit.

"April 11. On R. F. amplifier report. Designed case for A. C. amplifier.

"April 12. Further tests with A. C. amplifier, using negative C battery in R. F. grids. Gives little better results. More stable operation secured with about 80 to 100 volts on plates.

"April 13. Tests with A. C. amplifier. Revision of R. F. amplifier report.

"April 14. Revision of R. F. amplifier report. * * * Helped carpenter on case for A. C. amplifier.

"April 18. Fitted A. C. amplifier to its case. Designed horn to fit into case lid. Started carpenter making horn.

"April 20. Fixed up loud speaker and horn in cover to A. C. amplifier.

"April 22. Rubbed down and polished A. C. amplifier case. Worked on R. F. amplifier report.

"April 24. More work on A. C. amplifier. Trying to reduce R. F. oscillating when 3 R. F. stages are used.

"April 25. Worked on A. C. amplifiers.

"May 1. Worked on R. F. stages of A. C. amplifier. Trouble caused by R. F. oscillations producing loud hum when 3 R. F. stages used.

"May 2. On A. C. amplifier. Best operation obtained with only two R. F. stages.

"May 3. Finished construction of flexible loop for use with A. C. amplifier. Made up experimental amplifier set-up for making tubes at 100 meters.

"May 9. Tried iron core R. F. transformer wound different turns and forms, but at best was too restricted in range.

"May 10. Made up a tuned-plate amplifier stage using ½-inch square bakelite tube wound with 100 turns, fitted with sliding core for tuning. This gave good operations from 80 to 200 meters with controllable oscillations at any point.

"May 11. Making up a small variometer to try for tuned-plate coupling in place of tuned iron core choke.

"May 12. Worked on small variometer.

"May 18. Started writing 6 abstracts, 3 on A. C. amplifier and 3 on R. F. amplifier circuit.

"May 23. Writing abstracts of A. C. amplifier paper. Fixed up A. C. amplifier for taking its picture.

"May 24. Writing abstracts for A. C. amplifier paper.

"May 25. Writing and rehashing abstracts on A. C. amplifier paper; also radio-frequency amplifier paper."

There is the same entry for the 26th and the 27th of May.

"June 29. Completed wiring of amplifier sets."

The WITNESS. I have a book here and I recognize the handwriting in which most of the entries are made as being the handwriting of Mr. Dunmore. It is a laboratory notebook that was kept by Mr. Dunmore in 1920, 1921, 1922, and 1923.

Mr. HOLTZOFF. I offer this notebook in evidence.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 26.")

Mr. HOLTZOFF. There are a few pages in this notebook to which I would like to invite your honor's attention.

On page 38, the entry dated September 6, 1921, the heading of which is "Relay operated from tube."

Then we have an entry on September 15th, the heading of which is "Made additions to the above."

There is an entry on September 16th on the same page apparently referring to the same matter.

I then wish to call your honor's attention to page 40, the entry for September 23, 1921, showing a diagram with an explanation of the various portions of it, apparently relating to a relay.

On page 41 we have an entry dated October 7, 1921, which is headed, "New data on relay recorder."

Then follows a diagram with the statement, "This circuit is very selective to audio frequency, it being possible to tune out a signal of slightly different frequency due to different beat, note frequency.

Two recorders could record simultaneously off same antenna." It is signed "F. W. D."

Next I ask your honor to turn to page 46 of the notebook, the entry of December 8, 1921, referring to the recorder and relay, and then on the next page, December 8th, 1921:

"Also at Snow's suggestion I set up this circuit to give B battery voltage from A. C. line."

The WITNESS. Mr. Snow was a member of the radio section.

Mr. HOLTZOFF. The rest of the entry describes the particular experiment in detail.

Then I ask your honor to look at page 48, the entry for December 9th.

"Set up two tungars and rectified 60-cycle alternating current. This gave some hum, but with one rectifying tube it was not bad." Your honor will note a diagram on the side of this entry.

On page 49, December 10, 1921:

"Receiving set worked from A. C. line. Filament and plate power supplied from same." Then follows a diagram of the circuit.

"Tried the above. Only used one detector and two stages of audio. It worked but was insensitive. Got most of the hum out."

Then an entry on December 16, 1921, on page 50:

"Set this circuit up yesterday and got it working O. K. to-day. Can work the recorder from the 110-volt A. C. line using this power for the A, B, and C batteries, so no batteries whatever are necessary." Then follows a diagram. The circuit is given on the opposite page.

"Worked the recorder O. K. on the French set, using no antenna or ground and one stage of amplification. The following persons saw the recorder work: Morris S. Strock and Francis H. Engel." It is signed F. W. Dunmore.

The WITNESS. Mr. Strock and Mr. Engel were members of the radio section.

Mr. HOLTZOFF. On page 51 is the circuit diagram.

I then call your honor's attention to page 54, recorder transformer for 110-volt 60-cycle current, with a diagram of the transformer and a description of it, and a slip attached, in another handwriting, which I will later identify.

Page 54 has a similar entry.

On page 57 is the entry for January 20, 1922, "Complete A. C. radio receiver including loud speaker."

Then follows a diagram. Your honor will see two signatures in the lower right hand corner by F. W. Dunmore, January 20, 1922; and P. D. Lowell, January 20, 1922.

The WITNESS. I recognize these two signatures as being the writing of Mr. Dunmore and Mr. Lowell.

Mr. HOLTZOFF. Page 58, January 21st, 1922:

"Method of simultaneous transmission of three or more radio telegraph messages in the same wave lengths." Then follows a diagram with an explanation.

January 27, 1922, page 61, we have a heading:

"A Method of Remote Control of Radio."

Then comes a detailed explanation that runs over to the next page.

I might say, your honor, that that is what I had reference to in my explanation this morning when I spoke of this relay being used for remote control of airplanes or any other apparatus.

June 3, 1922, pages 64 and 65:

"P. D. Lowell and I doped out this circuit to-day which is given below. Three tubes and one heterodyne tube are used. The three tubes function at two different radio frequencies, and at audio frequencies a crystal is used."

Page 69, May 1, 1922:

"Method of utilizing polarized relay on Dunmore type A and B recorder."

Then follows a diagram with an explanation.

Then page 70, May 5, 1922, and written over that is a notation, "This should be June 5th." So I presume the preceding entry should be June 1st, rather than May 1st.

"Improved relay recorder. Thought this up on the 3rd of June, 1922, and showed the idea to Lowell. This idea gets rid of the grid voltage rectifier tube and gets the grid negative voltage from the plate supply tube."

Then follows a diagram with the notation, "Disclosed to P. D. Lowell, June 5, 1922."

The WITNESS. I have a book here and I recognize the handwriting in which most of the entries are made as the handwriting of Mr. Lowell's. It is his laboratory notebook, the entries being for 1922. It is produced from the files of my section.

Mr. HOLTZOFF. I offer this notebook in evidence.

The COURT. Admitted without objection.

(Notebook received in evidence and marked "Plaintiff's Exhibit No. 27.")

Mr. HOLTZOFF. I wish to call your honor's attention to page 22 of the notebook. Your honor will note that book apparently starts with page 21. If you will turn to page 22, the entry for Tuesday, January 10, 1922:

"Took up some experimental work in attempt to work tube receiver on 60-cycle supply for filaments and plates. Tried it on filaments only at first. First tried 1 radio-frequency stage detector and 1 audio stage as shown below."

Then follows the diagram, and on page 23, it says:

"It was found that grid potentiometers S^2 and S^3 helped greatly in reducing 60-cycle hum by virtue of keeping the normal voltage on the grids at zero.

"S^1 did not produce any results, so it is presumed that the RF transformer effectually blocks any 60-cycle frequency pulses from getting thru to detector.

"S^4 was used to prevent any variation in plate voltage due to 60-cycle filament supply.

"The above circuit was quite full of 60-cycle hum, although radio signals were received with it. A galena crystal detector was used in place of the tube detector and connected as shown below."

Then on page 24 follows a diagram, and then the following entry:

"This gave very good operation and was almost free from 60-cycle hum. It was thought that the residual hum was due to some other source other than variation in grid voltage because the grid biasing rheostat should keep the grids at zero voltage.

"The following circuit was tried to test this assumption."

And then follows the diagram; and a description of the circuit on page 25. Then, on page 26, "January 11th. The following circuit was set up." Then a diagram and a description of the circuit.

Page 27:

"A tube detector was tried again but connected without grid condenser and leak, the rectifying action being obtained by making the grid about 15 volts negative. Sketch below." And then follows the diagram.

"This gave a quieter circuit with less hum than the ordinary grid condenser detector circuit but the detector action is not as good.

"So far it seems that R. F. amplification with a crystal detector gives best results.

"It was thought that a telephone transformer with a 1 to 1 radio between the detector and phones might help, but it was found to be no improvement."

Page 29, January 12th.

"Spent all morning writing outline for Dr. Dellinger on proposed procedure in bridge and amplifier work."

The WITNESS. The "bridge" was the other task that Mr. Lowell was working on at that time. In radio the term "bridge" means a device for making measurements of the radio circuit such as resistances and capacity.

(Reading of notebook entries continued:)

Then I skip the next paragraph, and the third paragraph on that page—

"Some more circuits were tried in the amplifier to reduce the hum due to 60 cycles on filaments, especially when a tube detector is used.

Although the circuit employing 2 radio-frequency stages and crystal detector operates with a minimum hum, it is considered very bad to have to use a crystal detector, and further tests will be made so that a tube detector may be used, if possible."

Page 30. "A tube detector was tried again and various schemes tried to balance out the residual hum by feeding or inducing a back emf both into the grid and plate circuits but no further success was attained."

On page 31, January 13th:

"Went back to the two radio stages and crystal detector and put on one audio stage.

"The audio stage produced somewhat more of a hum."

"Next tried A. C. as source of plate voltage by rectifying about 80 volts with 1 electron tube (Moorehead) acting as rectifier. This rectified pulsating D. C. was smoothed out by means of a 20 microfarad condenser across the output. The standard rectification circuit was used (see diagram below)."

And then follows the diagram.

"The amplifier worked fairly well with this source of plate voltage, but the residual hum due to the A. C. filament current affecting the grids was quite bad.

"Think that this source of plate voltage is satisfactory, but something must be done to get rid of the hum caused by A. C. on filaments.

"Will try a Tungar rectifier to give D. C. for filaments next."

Then, I pass to page 35:

"Jan. 16. Mr. Dunmore and I continued work with the amplifier circuits in the attempt to use the 60 cycle power for filaments and plates.

"As was stated before, with the simple circuit shown below—"

And then comes the diagram—

"It was found that the 60 cycle hum could be balanced out by adjusting the voltage divider on the grid, which means that the normal grid voltage is at zero with respect to the filament at all times.

"But there is still a residual hum left which has a 120-cycle frequency. This is evidently due to the change in plate current with the change in brilliancy of the filament. The filament becomes brightest at two tunes during the A. C. cycle, once positive and once negative. Therefore the plate current rises and falls synchronously, giving the double frequency of 120."

Page 37, January 17th:

"It was found that the R. F. amplification could be considerably increased by inserting a condenser of about .02 microfarads in series

with the slides on the voltage divider, thus." Then follows the diagram.

"An audio frequency stage may be added after the crystal detector but with considerable increase in hum.

"The hum, however, can be materially reduced by introducing a series condenser of about .02 mfd. shunted by an 80,000 leak in series with the plate and telephone circuit."

"This condenser seems to obstruct the path of the 120-cycle hum while the higher frequencies pass through. The 80,000 leak allows the plate voltage to by-pass the condenser and reach the plate.

"It was also found that a condenser of about .02 microfarad in series with the grid voltage divider improved the amplification. This allows the grid to assume a better voltage for amplification instead of being held at zero by the stabilizer."

Page 39, January 18th:

"Have practically given up hopes of using a tube detector because of the bad hum present when it is used.

"When a tube detector and one audio stage is used the 120 ripple in the detector plate is amplified by the audio stage and increased to a great degree. But with a crystal detector there is no 120-cycle hum impressed on the grid of the audio tube, and therefore the only hum left is that which is in the plate circuit of the audio frequency amplifying tube.

"A rectifying circuit is being set up for producing rectified alternating current for the filament supply. For this purpose one Tungar bulb is used.

"Page 40. Jan. 19. The Tungar rectifier circuit was completed and the amplifier tried with the rectified alternating current on the filaments.

"It was found that the hum was much worse than when pure alternating current is used on the filaments. Evidently, when the alternating current is rectified, the wave form becomes unsymmetrical, thus—" and then follows a diagram.

"With this form of current on the filaments therefore it becomes impossible to stabilize its effect upon the grids by means of the voltage dividers and the hum can not be eliminated to any great extent.

"Page 41. January 20. Think it is more advantageous to use pure alternating current on the filaments as the hum can be more nearly eliminated.

"Tried a circuit with 2 radio frequency stages, crystal detectors and 2 audio stages with pure alternating current on filaments and rectified alternating current on the plate. Used the following circuit."

Then on page 42 is a diagram of the circuit and on page 43 and 44 is a detailed description of the circuit and then resuming at the bottom of page 44:

"This complete circuit works quite well, although there is some hum present, it is not very objectionable. The crystal detector, however, is the great drawback and its use, of course, is very undesirable and improper.

"It is still hoped, however, that the use of a tube detector is still possible without objectionable hum. Further schemes will be tried for its use."

Then on page 45, January 21: "Assisted Mr. Dunmore on some work with his recorder. Wrote in notebook.

"Page 46. Jan. 23. Dunmore and I tried a Magnavox loud speaker in conjunction with the amplifier, both amplifier and Magnavox being run on the 110-volt, 60-cycle power.

"The amplifier circuit shown on page 42 was used and the direct current for the Magnavox field soil supplied from alternating current rectified by a Tungar rectifier tube.

"Did not get good results for some unknown reason, there being a loud hum always present.

"Page 47. Jan. 24. Found a faulty connection in amplifier circuit and when this was fixed the amplifier and Magnavox worked very nicely, there being some 60 cycle hum present but not objectionable. A 55-volt winding was used on the transformer, this being rectified by a Tungar and when applied to Magnavox field coil, fell to about 4 volts, the large inductance of the field coil serving to smooth out the rectified alternating current.

"Helped Mr. Dunmore on some recorder tests.

"Page 48. Jan. 25. Tried a new form of amplifier circuit wherein the condensers in the grid circuits of the amplifier tubes are replaced by a negative grid battery of about 10 volts. This seemed to give a more stable circuit and to further reduce the hum somewhat. The circuit as it now stands—" then follows the diagram and another diagram on a sheet attached to page 49.

"Page 50. Jan. 26. The complete circuit disclosed on page 49 works very nicely, there being a negligible amount of hum present which is not objectionable. Radiophone speech and music was picked up from several places and reproduced with as much clearness as when batteries are used throughout.

"Of course the crystal detector is objectionable in a way, but the fact that the radio-frequency amplification before it produces a large electromotive force upon it, reduces this objection considerably. It was found that almost any old crystal operated well because of the

large electromotive force impressed upon it, making it more efficient in operation. It is thought advisable to have two sets made in the shop. One radio audio frequency amplifier with its transformer and rectifier tube and one Magnavox set with two audio power stages, transformer, Tungar rectifier, and loud-speaking Magnavox for the convenience of the laboratory, when it is desired to transport a receiver and loud-speaker to any place for demonstration purposes or for exhibitions such as was given by the bureau some time ago."

Page 52, we have the entry for January 27th:

"Made a few more trials at using electron tube detector in place of the crystal. Thought that the following circuit might help out." Then follows a diagram of the circuit and the following paragraph is a description of the circuit, and then the following entry:

"This did not help any so have given up idea of using tube detector.

"Jan. 28. Page 53. Helped Mr. Dunmore with his recorder experiments.

"Doped out a modulating circuit using a condenser microphone." Then follows the circuit and an explanation of the circuit:

"Page 54. Helped Mr. Dunmore on some recorder tests.

"Page 55. Jan. 30. Started on design for 5-tube amplifier worked on 60-cycle alternating current.

"Jan. 31. Started shop drawing for alternating-current amplifier.

"Feb. 1. Worked on shop drawings for alternating-current amplifier.

"Feb. 2. Mr. Buckley took over work on drawings for alternating-current amplifier. Helped Mr. Dunmore on tests with problem of sending two messages on one wave length by means of two audio-frequency notes working through recorders.

"Feb. 3. Page 56. Helped Mr. Buckley on drawings for alternating-current amplifier. Made some practical tests with alternating-current amplifier. Figured on arrangement of apparatus for transformer and rectifier unit to go with alternating-current amplifier.

"Conferred with Dr. Brooks regarding construction of 60-cycle alternating-current transformer for alternating-current amplifier.

"Feb. 4. Conferred with Mr. Buckley regarding details of alternating current amplifier drawings. Made some tests with rectified A. C. on field coil of Magnavox. Find that about 100 volts A. C. when rectified with Tungar gives almost proper current through magnavox.

"Page 57. Feb. 6. Worked with Mr. Buckley on drawings for A. C. amplifier. Trying to make set as compact as possible and

portable. Will be ready for mechanician to start about Thursday of this week.

"Assisted in tests with Dunmore's recorder. F. W. D. and Baer at latter's home, receiving, and I at bureau, sending. Tests not very satisfactory, due to faulty transmitter."

I pass to page 58, the entry of February 8th:

"Tried various voltages on Tungar plate to be rectified for Magnavox field coil, trying to get six volts direct current into same.

"Found that 120 volts A. C. applied directly to Tungar with reactance in series gave proper results. Circuit—"

Then follows a diagram of the circuit with a description of the circuit on the following page.

"Page 60. Feb. 9. Made a transformer according to specification of Mr. Sanford, magnetic section. Transformer has 5 windings as follows:" Then follows a description of the transformer, and I pass to page 61, February 10th.

"Started design for rectifying unit for A. C. amplifier and magnavox. Unit will contain A. C. power transformer, plate voltage rectifier tube, and 12 microfarads condenser. Tungar tube rectifier and filament control rheostat. All will be contained in a closed box which will be easily carried and provided with a lamp cord and plug for connecting to A. C. power mains.

"Page 62. Feb. 11. Tried some tests with magnavox, one and two stages audio-frequency amplification and microphone on the input. It was found that the ordinary audio-frequency transformers produce considerable speech distortion due to their rather sharply tuned characteristics.

"General radio modulation transformers gave much better trial values.

"It is thought that a transformer special design will be better or possibly a resistance coupled type of audio-frequency amplifier.

"Page 63. Feb. 13. Wrote up report for publication on A. C. amplifier. Tried out 2 stages of resistance coupling for audio-frequency amplification. Used French type 80,000 ohm coupling resistances and .02 microfarad coupling condenser.

"This type of coupling gave very good quality in speech or music amplification but with not as much amplification per stage as transformer coupling, which is to be expected.

"Feb. 14. Worked on shop drawing for rectifier unit to go with A. C. amplifier. This unit to include power transformer, plate rectifier tube, Tungar rectifier tube, smoothing out condenser of 10 microfarads and filament rheostat for plate rectifier tube.

"Page 64. Feb. 16. Conferred with Ould on publication of report on A. C. amplifier. Made 10 circuit diagrams for him to go with report. Changed filament windings on power transformer for alter-

nating current amplifier, they had too many turns on them. Investigated catalogues for purpose of ordering some parts for A. C. amplifier."

The WITNESS. The duties Mr. Ould performed in connection with publications of the radio section were serving as an assistant to the chief of the section on publication matters.

(Reading of notebook entries continued:)

"Page 65. Feb. 17. Worked on shop drawing for A. C. rectifier unit for amplifier.

"Feb. 18. Made a few more tests with A. C. current amplifier set-up using modulation transformers in audio-frequency stages. Modulation transformers gave better quality amplification on radiophone speech and music but not so much amplification of signals. Tried choke coils in series with plate voltage supply on direct current side of rectifier tube. They helped some to eliminate hum in telephone receivers.

"Page 66. Feb. 20. Started on construction of A. C. amplifier. Got together all necessary parts available. Got bakelite from Preston and Signal Corps for panels and shelf. Cut and drilled top panel. Five hours in shop."

"Feb. 21. Worked on A. C. amplifier construction in shop. About six hours.

"Feb. 23. In shop on A. C. amplifier work. About six hours.

"Feb. 24. Worked in shop on A. C. amplifier mounting transformers, sockets, and other parts. About six hours."

Page 67. "Feb. 25. Worked in shop on A. C. amplifier. Assembling and mounting parts. About six hours. Made new telephone transformer"—then follows a diagram with an explanation.

Page 68. "Feb. 27. Worked on A. C. amplifier in shop, assembling and mounting. About five hours." And a similar entry on February 28th.

"March 1. Finished shop work on A. C. amplifier unit. Rectifier unit still not made.

"March 2. Started wiring up A. C. amplifier.

"March 3. Finished wiring A. C. amplifier.

"March 4. Made tests with finished A. C. amplifier. Encountered much hum. Spent time trying to make it work properly.

"March 6. Worked with amplifier, trying to get hum out. Checked over wiring. Tried battery on filament and rectified A. C. on plates. Still much hum, so must be coming from A. C. on plates.

"March 7. Worked with battery on filaments and tried to quiet down rectified A. C. on plates. Found several smoothing out condensers in bad shape. Put additional choke coil in plate line. Finally got much better results.

"March 9, page 71. Worked more with elimination of hum in amplifier. Rectified A. C. seems to be O. K. now. Still some hum when A. C. is used on filaments, but not objectionable.

"March 10. Made some more tests with A. C. on both filaments and plates. Took some turns off the filament windings on power transformers as filaments were too bright. Amplifier seems to be about as quiet and free from hum as could be expected.

"March 11. Continued testing out A. C. amplifier. Started writing report on radio-frequency amplifiers.

"Page 72. March 14. Made some changes in A. C. amplifier circuit, putting in a 1-microfarad condenser from radio-frequency grids to radio-frequency stabilizer armature. Also put 1 microfarad condenser from cup of crystal detector to one side of filament supply. The latter condenser seemed to aid somewhat in reducing hum.

"Also made changes in rectifier circuit as shown in sketch below." And then follows a diagram with explanation, and then I pass to the entry for March 15th, on page 73.

"Made more tests with A. C. amplifier.

"March 16. Planning assembly arrangement of rectifier unit to go with A. C. amplifier. Demonstration of laboratory apparatus to visitors.

"March 17, page 74. Worked on design for rectifier units.

"March 18. Made more tests with A. C. amplifier. Conferred with Dr. Miller regarding operation of A. C. amplifier. Will get Mr. Buckley to make shop drawings for rectifier unit.

"Page 75, March 20. Made more tests with A. C. amplifier. Trying to further reduce the hum. Found that circuit worked best with ground connections on filaments."

I then pass to page 78, March 27: "Worked on drawings for design of rectifier units for A. C. amplifier.

"Will not incorporate Tungar rectifier for magnavox in this unit, but will have only power transformer, rectifier tube for amplifier plate voltage, smoothing out condensers and filament rheostat.

"March 28. Made up temporary mounting of plate rectifier apparatus to take outfit home to try on power line there.

"March 29. Worked on drawings for rectifier units. Helped Dunmore on receiver for 100 meters.

"March 30, page 79. Made some tests using a detector tube with A. C. on filament, grid being connected to stabilizer slide. Get fairly good detecting action, but when audio stage is added hum becomes too loud.

"Found could balance out 120-cycle hum by using 2 tubes, one to amplify and another to produce hum for neutralizing."

Then follows a diagram.

"Page 80. This circuit, however, is too complicated and expensive for general use.

"April 1. Worked on drawings for rectifier unit.

"Page 81. April 3. Finished drawings for rectifier units. Started its construction in shop. Cut bakelite panels and drilled holes. Made over filament and rheostat. About 4 hours in the shop."

A similar entry for April 4th, 5th, 6th, and 7th.

"Page 82. April 8. Started carpenter on making cases for A. C. amplifier and rectifier units. Made loud-speaking horn to fit into A. C. amplifier. Finished rectifier unit in shop. About 1 hour.

"Page 83. April 10. Worked on radio-frequency amplifier report. Worked on rectifier unit for A. C. amplifier. Had to make some changes to enable carpenter to fit it into box.

"April 11. Drew up design for case for A. C. amplifier.

"April 12. Made some more tests with A. C. amplifier. Think a little better operation is obtained by using a negative C battery in the radio-frequency grid in place of a condenser. Have a little trouble with radio-frequency oscillations causing 60-cycle hum. Works best with plate voltage not over 80 or 100 volts.

"Page 84. April 13. Worked more on A. C. amplifier. Think it advisable to put in switch to permit use of 2 radio-frequency stages when desirable. Started carpenter on case for amplifier. Making further revisions in radio-frequency amplifier report.

"April 14. Helped carpenter on case for A. C. amplifier.

"April 15. Conference with men in textile section re possibility of weaving a tape with strands of wire in it. To be used for flexible folding loop for A. C. amplifier unit. Mounting variable condenser in amplifier set."

By Mr. HOLTZOFF:

Q. Did the Bureau of Standards have a textile section?

Mr. HUGHES. I object unless the authority of such section is shown, if the court please.

The COURT. The objection is overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

A. Yes.

(Reading of notebook entries continued:)

"Page 85, April 18. Case for A. C. amplifier completed, fitted instrument to case. Designed wooden horn to fit in cover to case. Started carpenter making horn.

"April 19. General laboratory work. Demonstrations to visitors. Designing folding loop for A. C. amplifier. Will use wires sewed into cloth tape which will roll up and fit in lid of amplifier.

"April 20. Fixed out loud-speaking horn for A. C. amplifier to fit in lid of case. Used an old Firth Decremeter phone as loud speaker. Seems to be very good.

"Page 86, April 22. Rubbed down and polished cabinet for A. C. amplifier and rectifier.

"April 24. More tests with A. C. amplifier. Trying to eliminate radio-frequency oscillating which causes hum. Find best results obtained with two radio-frequency stages rather than 3 stages on account of trouble with oscillations with 3 stages. Find large capacity in tuning circuit gives better operation.

"April 25, page 87. Think A. C. amplifier is about as good as can be made at present time.

"April 26. Talked with visitors, who inquired regarding A. C. amplifier.

"April 27. Amplifier worked very nicely on music from NOF using small antenna, one audio stage sufficient. Picked up KDKA, but his signals a little too weak to overcome interference from A. C. hum. Conferred with Mr. Diaz regarding drawings for radio-frequency amplifier report.

"April 28. Experimented with radio-frequency transformers for A. C. amplifier trying to make 3 stages work better without radio frequency oscillating.

"April 29. Experimented with radio-frequency transformers in A. C. amplifier.

"Page 89, May 1. Worked on radio-frequency stages of A. C. amplifier. Tried different windings on radio-frequency transformers, have trouble with radio-frequency oscillations causing 60-cycle hum in phones.

"May 2. More tests with radio-frequency stages in A. C. amplifier. Seems to be best with only 2 radio-frequency stages.

"May 3. Finished construction of flexible loops to go with A. C. amplifier. Made up experimental amplifier set-up for 100-meter amplification."

Then I pass to page 92.

"May 10. Made up amplifier circuit with tuned plate coupling using a coil wound with No. 36 silk-covered wire wound on a one-half inch square bakelite tube, 100 turns. Iron core arranged for sliding in and out to tune with circuit."

Then follows a circuit diagram with an explanation. I then pass to page 97.

"May 18. Started on writing up abstracts on A. C. amplifier and radio-frequency amplifiers. Six abstracts to be written.

"May 24. Writing abstracts for A. C. amplifier. Fixed up A. C. amplifier for taking its picture."

A similar entry on May 25th, May 26th, and May 27th.

The WITNESS. This paper I have is a monthly report of Mr. F. W. Dunmore for August, 1921. It is in Mr. Dunmore's handwriting. I am not certain that I recognize the initials at the bottom of the page. The initials are in pencil while the report is in ink. I recognize the writing of his name at the top, but I am not certain as to the initials. It is one of the regular monthly reports that were required to be filed with me by the members of my staff, and it is produced from the files of my office.

Mr. HOLTZOFF. I offer in evidence the monthly report of F. W. Dunmore for August, 1921.

The COURT. Admitted without objection.

(Received in evidence and marked "Plaintiff's Exhibit No. 28.")

Mr. HOLTZOFF. I wish to call your honor's attention to the first paragraph of this report:

"Work was started this month on the development of an electron tube operated relay for the Air Service to be used in connection with the remote control of airplanes. The method of operating a relay in the plate circuit of a tube when the tube is set into the oscillating condition was adopted."

Then follows a technical description of what was being worked on.

The WITNESS. This paper I have is headed monthly report for September, 1921, F. W. Dunmore, and it is a monthly report for the month in question by Mr. Dunmore. It is produced from the original files of my office.

Mr. HOLTZOFF. I offer it in evidence.

The COURT. Admitted without objection.

(Received in evidence and marked "Plaintiff's Exhibit No. 29.")

Mr. HOLTZOFF. I call your honor's attention to the first part of this report.

"The greater part of this month has been devoted to the development of a type of recorder by means of which a radio signal may be made to operate a relay. This work is in connection with project 42 for the Air Service and has to do with the remote control of an airplane by radio. This recorder in its present stage of development is constructed and functions as follows:"

Then follows a detailed technical description and on page 3 of this report we find the following entries:

"This type of radio relay has numerous advantages.

"1. Due to the fact that the relay is of simple construction and operates with a very positive action without great delicacy of adjustment it may be used in places where vibration is excessive, such as on an airplane for example.

"2. For ordinary reception the operator need not wear phones and may receive from an ordinary sounder if he is so trained.

"3. Any mechanism may be controlled by the relay.

"4. It is readily adaptable to any receiving set where sufficient amplification is to be had, as it may be plugged in the socket where the phones ordinarily go.

"5. Where induction noises and static are not much louder than the received signal they may be completely cut out as the relay armature may be so weighted that due to its inertia the quick kicks due to static will not pull it over, whereas the signal, lasting for a period of time somewhat greater than ordinary static, will operate the relay."

The WITNESS. This paper I have is headed "Monthly report, October, 1921, F. W. Dunmore," and it is the report for the month in question in Mr. Dunmore's handwriting.

Mr. HOLTZOFF. I offer it in evidence.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 30.")

Mr. HOLTZOFF. I call your honor's attention to the first part of this paper: "Work was continued this month on the radio recorder for remote control of airplanes. It was found that a variable condenser caused by the secondary of the audio transformer made possible audio tuning which greatly increased the selectivity." Then there are some more technical comments, and a summary of the work.

The WITNESS. This paper I have is headed "Report of Work from November 1 to November 15, 1921, F. W. Dunmore," and it is Mr. Dunmore's report for the period in question in his handwriting.

Mr. HOLTZOFF. I offer this paper in evidence.

(Received in evidence and marked "Plaintiff's Exhibit No. 31.")

Mr. HOLTZOFF. There are no entries there of any particular importance, but I am putting this in evidence to show the continuity of research work carried on by Mr. Dunmore at the bureau.

The WITNESS. I have a paper here entitled "Monthly Report, November 15 to December 15, 1921, F. W. Dunmore," and it is Mr. Dunmore's report in his own handwriting for the period in question.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 32.")

Mr. HOLTZOFF. I wish to call your honor's attention to the second paragraph of this report:

"The radio receiving relay for remote control by radio was wired up on a panel and enclosed in a case."

Then follows a technical description.

Then we have this statement:

"Tests were made on the completed recorder to determine its speed of operation and selectivity. During a Navy test on the

Teletype (printing telegraph typewriter) the recorder was satisfactorily used to operate the Teletype by radio. Tests were also made to increase the selectivity of the recorder by using audio tuning in the 2 stages of amplification used with the recorder."

Then on page 2, beginning at the middle of the page:

"Experiments were made to determine the possibility of using the 110 A. C. supply to replace the 160-volt C battery used in the recorder. It was found that by using one receiving tube of a rectifier, and a 4 microfared condenser and a 7 Henry coil to smooth out the rectified D. C., that 160 volts D. C. could be obtained, which could be used to replace the B battery. This improvement makes possible the operation of the recorder from the 110 volt A. C. line, as both filament and plate current are now obtained from that source. The elimination of storage cells to operate the filaments and dry cells of high voltage for the plate are steps which make the recorder a practical and useful device."

Then on the next page:

"Experiments were also made to find a means of operating the tubes as a receiving set from the 110-volt A. C. supply. Only partial success was attained."

The WITNESS. This paper I have, headed "Monthly Report, December 15 to January 15, 1922, F. W. Dunmore," is Mr. Dunmore's report in his own handwriting for the period stated.

Mr. HOLTZOFF. I offer this report in evidence.

(Received in evidence and marked "Plaintiff's Exhibit No. 33.")

Mr. HOLTZOFF. I call your honor's attention to the first part of this report.

"Development work on the new type B recorder was completed this month. It was found that the recorder could be successfully operated from the 110 A. C. 60-cycle line, the filament current plate and grid voltages being successfully obtained from this source. Material was collected and drawings made for a cabinet and panel to contain a type B recorder. A circuit diagram for the above recorder was drawn up and the report modified to include the new type recorder. A copy of this report was sent to the Journal of the American Institute of Electrical Engineers for publication.

"A tape register was received this month and connected up to the type A recorder. Tests were made to determine the speed of operation. It was found that 45 words per minute was the limit of this particular Bunnell register. It is the ink tape type. Tape record of radio central at Long Island was successfully made at 45 words per minute. Good tape record was also gotten on P. O. Z. Germany. A Western polarized high speed relay was tried out with the recorder to replace the ordinary relay now used. This relay was not as well adapted to the recorder circuit as the old one."

Then on the next page, the third paragraph:

"A method of selective control by radio was thought out in connection with Air Service project No. 42."

Then follows a technical description of the proposal.

Then there is the following entry:

"The best transformer design for supplying the filament voltage, grid and plate voltages was worked out and a transformer made up. Data on this transformer was carefully recorded so that it may be duplicated."

The WITNESS. This document entitled "Monthly Report, January 15 to February 15, 1922, F. W. Dunmore," is his report in his own handwriting for the month in question.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 34.")

Mr. HOLTZOFF. I call your honor's attention to the first paragraph of this report:

"The first type B relay recorder was completed this month. A Bunnell and Morkrum relay were tried out with this recorder. Although the Morkrum relay may be operated at higher speed, the Bunnell relay was somewhat easier to adjust, and so was used. The coils were rewound with a total of 22,000 turns of No. 38 wire. With three or four milliamperes in these windings, a very positive pull is obtained on the armature. The tests on the completed relay recorder showed it to operate entirely satisfactorily with the A. C. current as the only source of power.

"By the use of the audio-tuning feature on the types A and B recorders, several interesting tests were made."

The WITNESS. The distinction between type A and type B recorders is that type A uses direct current for power supply and type B uses alternating current.

(Reading of monthly report continued:)

"NSS was tuned in, and the two recorder inputs put in series and connected to the output of the audio amplifier. One recorder was adjusted to operate on the note of the sending wave, and the other adjusted to operate on the spacer wave. Simultaneous tape record was then made, one of spacer wave, the other the sending wave. By adjusting the tuning to a point where two stations could be heard sending at the same time, the pitches being different, two messages were recorded at the same time from two of the high-power stations of this size.

"As a result of these tests, the possibilities of duplex and triplex transmission on one wave length were realized. The method consists of modulating the output of a continuous wave generator, at two or more audio frequencies. The transmitting keys are in the

audio modulating circuit. Different types of modulators were tried, choppers, buzzers, and tube generators oscillating at audio frequencies. The latter proved most satisfactory. Thus far two messages have been transmitted on the same wave length over a very short distance. These messages were received one on the one recorder, the other on the other recorder, both recorders being on the same antenna.

"At the request of the Navy Department, Dr. Miller made tests on the type A and B recorder and submitted a report on same."

Then towards the bottom of the page:

"Some work was done with Mr. Lowell on the development of a radio-audio amplifier operated entirely from the A. C. supply."

And then the last paragraph:

"A plan of procedure on short-wave transmission for the Air Service was worked out and material gotten together to start it."

It is signed "F. W. Dunmore."

The WITNESS. This document entitled "Monthly Report, February 15th to March 15th, 1922, F. W. Dunmore," is Mr. Dunmore's report to me in his handwriting.

Mr. HOLTZOFF. I offer this document in evidence.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 35.")

Mr. HOLTZOFF. I call your honor's attention to the second paragraph of this report:

"The type A recorder was overhauled and new B and C batteries put in same. Tests with the type A and B recorders connected in series each working a tape register showed that it was possible to make a record of the spacer wave and sending wave of NSS simultaneously.

"Another application of the recorder was worked out on paper, whereby a radio compass may be made to be self-setting."

Then follows a technical description of how that is to be done.

Then on page 3:

"400 dollars was set aside by the Navy for the construction of two type B recorders. Work was started for the Signal Corps building parts of two type B recorders which they have ordered. The type A recorder was loaned to Navy Dept. for comparison test with the Bruce relay."

Skipping the next paragraph, there is another entry:

"Proofread recorder paper which is to come out in the April issue of the A. I. E. E."

Then skipping the following paragraph:

"Several suggestions were given to Lowell on the development of the A. C. amplifier and his report on same was proofread."

The WITNESS. This paper I have entitled "Monthly Report, March 15 to April 15, 1922, F. W. Dunmore," is Mr. Dunmore's report to me for the period in question and is his handwriting.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 36.")

Mr. HOLTZOFF. I call your honor's attention to the latter portion of page 2:

"Took A. C. amplifier home and made tests with it, both on the loop and using the power line as antenna. Dr. Dellinger also made the power line tests with me. Signals were weak on power line. A couple of the permanent set-ups were put in working order."

Then skipping the next two paragraphs:

"Working drawings of the type B relay recorder were started."

The last paragraph:

"The final design of A. C. amplifier was decided upon after talking over the question with Mr. Lowell. The amplifier is to contain a horn and collapsible loop in the cover with a loop tuning condenser in the body."

The WITNESS. This paper I have, headed "Monthly Report, April 15 to May 15, 1922, F. W. Dunmore," is Mr. Dunmore's report to me in his own handwriting for the period in question.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 37.")

Mr. HOLTZOFF. I call your honor's attention to the first paragraph of this paper:

"Some time was spent this month in getting a detail drawing of the recorder drawn up. Assistance was also given to the Signal Corps in getting two recorders built up for their use.

"A trip was made to Chicago to present a paper on a Relay Recorder for Remote Control by Radio at the convention of the A. I. E. E."

The WITNESS. This document entitled "Monthly Report, May 15th to June 15th, 1922, F. W. Dunmore," is Mr. Dunmore's report to me for that period in his handwriting.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 38.")

Mr. HOLTZOFF. I call your honor's attention to page 2 of this report, the first full paragraph:

"Two type B radio receiving relays were finished for the Signal Corps and tested out this month. They both worked entirely satisfactorily. Tape record was obtained on Fort Wood, N. Y., with a

detector and 2 stages of audio used with the recorder. Also with a good, strong signal it was found possible to operate the relay on a note below audibility. The relay was demonstrated to officials of the Signal Corps and tests are to be made under their actual working conditions.

"The set of detailed working drawings on the relay has been about completed this month. Some time was devoted to details connected with this work.

The WITNESS. This paper I have, entitled "Report for November 15 to December 15, 1921, P. D. Lowell," is the monthly report of Mr. Lowell for November 15 to December 15, 1921, in Mr. Lowell's handwriting.

Mr. HOLTZOFF. I offer this in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 39.")

Mr. HOLTZOFF. I am just putting this in to show the continuity of Mr. Lowell's work. There is no particular entry that bears upon the work here in suit.

The WITNESS. This report I have here, signed "Respectfully submitted, P. D. Lowell," headed December 15, 1921, to January 15, 1922 is Mr. Lowell's report to me in his own handwriting for the period in question.

Mr. HOLTZOFF. I offer this document in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 40.")

Mr. HOLTZOFF. I call your honor's attention to page 2 of this report, the first full paragraph:

"Some experimental work has been done to determine the feasibility of using a 60-cycle 110-volt lighting current as a source of filament and plate voltages in an electron tube receiver both in radio-frequency and audio-frequency amplification and detector. Various amplifier circuits were tried, and it was found that probably the best combination was when radio-frequency alone was employed and a crystal detector used, the latter use is very objectionable in such a circuit, because of its instability, and further tests will be conducted to utilize a tube detector if possible. The hum due to the alternating current on the filament was reduced to a minimum by employing voltage dividers on the grids so as to keep the grids always at normal zero tension. Some hum is still present in spite of this, due to the change in filament temperature, which affects the grid voltage. Several means were tried to balance out this residual hum, but with little success. A crystal detector gave a much better operation than the tube detector, but its use is very impractical. The best circuit is shown below."

And then follows a circuit diagram, and then on the next page:

"The use of alternating current on the plates was next tried with very good results with filaments. A one-tube rectifier was used to rectify the 80 volts from the transformer and a 20-microfarad condenser used to smooth out the voltage. This worked very nicely and gave very quiet operation, as good as high-voltage batteries for all ordinary purposes. The rectifying circuit is here shown."

And then follows the circuit diagram:

"Further tests will be made in an effort to entirely eliminate the hum due to the alternating current on the filaments, also to use a tube detector in place of the crystal, and to use alternating current on the filaments and plates simultaneously.

"Respectfully submitted. P. D. Lowell."

The WITNESS. This paper I have, headed "Monthly report for January 15 to February 15, 1922, signed P. D. Lowell," is Mr. Lowell's report to me in his handwriting for that period.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 41.")

Mr. HOLTZOFF. I call your honor's attention to the first paragraph:

"Work was continued on the problem of using the 110-volt A. C. power for the filaments and plates of an electron-tube amplifier. It was found that the amplification could be considerably increased by introducing condensers of 0.02 microfarads capacity in the grid circuits of the amplifier tubes. These condensers, however, were later replaced by a battery which impressed about 10 volts negative charge on the grids. This gave maximum amplification with a minimum of hum.

"The possibility of using a tube detector was practically given up because of the large amount of hum present when it is used. A good galena crystal detector gave practically as good rectification and helped to reduce the hum immensely.

"The use of A. C. rectified by a Tungar, on the filaments was tried and abandoned because of the distortion of the wave form during rectification, which made it impossible to balance out the hum in the grid circuits.

"Rectified A. C. on the plates worked very nicely, an ordinary amplifier tube being used to rectify 300 volts A. C. This was smoothed out by a 20-microfarad condenser. The D. C. output from the rectifier tube would be varied from 10 volts to 300 volts by adjustment of its filament temperature.

"It was found that a one-to-one ratio telephone transformer helped to reduce the hum in the receiver.

"A Magnavox loud-speaking telephone was also introduced into the circuit and it was found that its field coil could be operated on the A. C. power by use of a Tungar rectifier which gave 6 volts D. C. across the coil. The high impedance of the field coil served to smooth out the rectified A. C. An additional choke in series helped to reduce the hum in the loud speaker.

"The final circuit, as developed, consists of 3 stages of radio-frequency amplification, crystal detector, two stages of audio-frequency amplification, together with the Magnavox, if desired and the power transformer and the rectifier circuit.

"Shop drawings have been made for two units, the 5 stage-amplifier unit and the rectifier unit. Investigation seems to show, however, that the possibility of having these constructed in the shop is very remote.

"Respectfully submitted.

"P. D. LOWELL."

The WITNESS. This paper, headed "Monthly Report, February 15 to March 15, 1922," is Mr. Lowell's report to me in his handwriting for the period in question.

Mr. HOLTZOFF. I offer this document in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 42.")

Mr. HOLTZOFF. (Reading.) "Preliminary experimental work on the A. C. amplifier was completed and the construction of a finished amplifier started in the shop. This set was completed and after some further experimenting was made to operate very satisfactorily. The rectifier unit to go with the amplifier unit has not been constructed yet.

"The operation of the whole set was improved somewhat by the addition of a condenser here and there to help reduce the hum.

"A complete report on this subject has been completed and all details are incorporated therein."

The WITNESS. This document headed "Monthly Report for March 15 to April 15, 1922," is Mr. Lowell's report to me in his handwriting for the period in question.

Mr. HOLTZOFF. I offer this in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 43.")

Mr. HOLTZOFF (reading): "The construction of the amplifier unit which operates on the 60-cycle power circuit has been completed with the exception of a collapsible loop antenna and a tuning condenser. The rectifier unit has also been completed. The loop antenna will consist of several strands of wire sewed into a cloth band, which can be rolled up and stowed in the cover to the amplifier."

The WITNESS. This paper, headed "April 15 to May 15, 1922, P. D. Lowell," is Mr. Lowell's report to me for that period in his own handwriting.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 44.")

Mr. HOLTZOFF (reading): "Experimental work on the amplifier operated from the 110-volt 60-cycle power has been suspended and a complete portable set made up in the shop. This set consists of two units, the amplifier and the rectifier. The amplifier has been fitted with a loud-speaking telephone and a folding loop antenna which is about 10 feet on a side when opened out.

"A report on this A. C. operated set has been made and submitted for publication. It will probably appear in the July issue of A. I. E. E."

The WITNESS. This paper, headed "Monthly Report, May 15 to June 15, 1922, P. D. Lowell," is Mr. Lowell's report to me for that period in his handwriting.

Mr. HOLTZOFF. I offer the paper in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 45.")

Mr. HOLTZOFF. "The writing of the paper on High Frequency Amplifiers and one on the Development of the Amplifier using A. C. supply has been completed as well as the six abstracts which go with them."

The WITNESS. This paper I have, headed "Monthly Report for June 15 to July 15, 1922, P. D. Lowell," is Mr. Lowell's report to me for that period in his own handwriting.

Mr. HOLTZOFF. I offer this paper in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 46.")

Mr. HOLTZOFF. I call your attention to the second paragraph, if your honor please:

"A radio time signal receiver and relay has been constructed and tested out for the clock section of the bureau."

And then follows a technical description of the apparatus.

By Mr. HOLTZOFF:

Q. Dr. Dellinger, what activities were undertaken or pursued by the bureau in connection with the publishing of the results of research that were done by members of the bureau staff at the bureau?

Mr. HUGHES. Objected to, if the court please, until it is established that this was an authorized publication, or publications authorized under the organic act or subsequent legislative acts.

The COURT. All of the question objected to is overruled.

Mr. HUGHES. Exception.

A. The man or men engaged in the work prepared a description of it, with a view of this description being published, together with certain abstracts, the whole being brought to the attention of the chief of the section in which the work was done and approved by him. It was then submitted to the chief of the division of which the section was a part, then considered by the bureau editorial committee and approved by it, finally approved by the director, and then sent through the process of printing or publication.

The COURT. Do I understand that is the universal practice?

Mr. HOLTZOFF. Yes, sir, if your honor please.

Mr. HUGHES. I object and ask the answer be stricken out. In the first place it is immaterial to the issues here. We are not concerned with what the bureau did by way of publication, if it could do anything legal; secondly, the legal right of the bureau to publish anything has not been established; thirdly, the answer is not responsive to the question.

The COURT. The three objections are overruled.

Mr. HUGHES. May I have an exception?

The COURT. Let an exception be noted. I gather it is the practice of the bureau to publish its own work for publication?

Mr. HOLTZOFF. Yes, sir. Sometimes the bureau, it has been testified to by the witnesses, either publishes the results of research work in publications that are printed under its own auspices, and sometimes they are sent to various scientific journals for publication; one or the other method is followed, as was testified to by the witness.

Mr. HUGHES. I call attention to the fact that Dr. Dellinger is the chief of only one of many sections of the bureau. He is not qualified to testify, I take it, as to what other sections do or what the bureau as a whole may do, except as instructions come to him.

The COURT. If he has the knowledge, I think he is authorized to testify.

The WITNESS. This paper I have is certified to by the Secretary of Commerce, entitled "Editorial Record," and contains the entry "Title of Paper, A Relay Recorder for Remote Control by Radio," "Title of author, F. W. Dunmore, Associate Physicist," and it is a sheet entitled "Editorial Record," the type of sheet which is attached as a matter of routine to each paper submitted for publication by the bureau. This particular editorial record sheet being for a paper, "A Relay Recorder for Remote Control by Radio, by Mr. F. W. Dunmore," for publication in the Journal of the American Institute of Electrical Engineers.

By Mr. HOLTZOFF:

Q. I call your attention to the entry "Signature of author," and I ask you if the name F. W. Dunmore is Mr. Dunmore's signature at that point, or rather, a photostat of his signature?

Mr. HUGHES. I take it this paper is to be offered in evidence before this testimony is accepted?

Mr. HOLTZOFF. Yes; I shall be glad to follow that suggestion. I was going to explain its contents first, but I think your suggestion is well taken. I offer this in evidence.

Mr. HUGHES. We object.

The COURT. What is the relation?

Mr. HOLTZOFF. To show that through the bureau channels there was a paper prepared and published, giving the results of this research, with the approval of the various bureau officials.

The COURT. Research relating to these patents or any one of them?

Mr. HOLTZOFF. To the radio relay.

Mr. HUGHES. How is that material to what was done by way of publication? We object to this paper on the ground that it is wholly immaterial, if the court please.

The COURT. Have you an answer, Mr. Holtzoff?

Mr. HOLTZOFF. Yes; I consider it material, and quite important, because it shows that Mr. Dunmore treated this work as one of his duties as a member of the bureau staff, otherwise, he would not have published this paper through bureau channels. If it had been, for instance, a private project, he would not have asked the permission and approval of his superiors to publish this as a bureau paper. I think that has some probative value on that score.

The COURT. I am inclined to agree with you. The publication is a bureau publication?

Mr. HOLTZOFF. Yes.

Mr. HUGHES. One minute; let us see what this publication is; where is the bureau publication?

Mr. HOLTZOFF. This particular record [handing].

Mr. HUGHES. This is not a bureau publication. This is a publication of the American Institute of Electrical Engineers.

Mr. HOLTZOFF. It was an article emanating from the bureau, a publication emanating from the bureau. As I have stated a few moments ago, it was the testimony of Mr. Boutell that some papers prepared at the bureau, were published by the bureau itself; other papers were prepared in the same manner and approved in the same manner, but were sent for publication to various technical journals and periodicals. In either event, they were publications emanating from and with the approval of the bureau.

The COURT. Has the publication of this particular article been traced to the bureau?

Mr. HOLTZOFF. Yes. This paper traces the publication, and I am going to follow this exhibit up by offering the publication itself in evidence.

Mr. HUGHES. That is not the court's inquiry.

The COURT. What does that paper show?

Mr. HOLTZOFF. May I show this paper to your honor?

The COURT. Yes.

Mr. HOLTZOFF. This paper shows or purports to show that Mr. Dunmore submitted a paper on the Radio Relay Recorder for publication to his superiors, and it was initialled by the section chief, and the division chief, and the members of the bureau editorial committee, and finally approved by the director of the bureau giving approval to the publication of the paper.

The COURT. Is the article itself here?

Mr. HOLTZOFF. The article itself is here in court, and I am going to offer it in evidence immediately after this paper.

The COURT. This is introductory?

Mr. HOLTZOFF. This is introductory.

The COURT. Dunmore, does he request the publication of his article?

Mr. HOLTZOFF. Not in so many words; but this editorial record sheet is a document that is to accompany the paper, which is later published.

The COURT. I think as a document—is it signed by Mr. Dunmore?

Mr. HOLTZOFF. Yes.

The COURT. Signed by Dunmore and transmitted to his bureau, which led to the bureau treating his paper as bureau property, that it has some relevancy in this case. Therefore, it is admitted.

Mr. HUGHES. Exception.

The COURT. Let an exception be noted.

(Received in evidence and marked "Plaintiff's Exhibit No. 47.")

The WITNESS. I identify the signature of Mr. Dunmore on this paper as being a photostat of his original signature. The signature at the bottom of this paper is that of S. W. Stratton, the director of the bureau.

Mr. HOLTZOFF. Now, I offer in evidence the Journal of the American Institute of Electrical Engineers, volume 41, page 4, being the issue for the month of April, 1922, and especially the article contained in that periodical headed, "A Relay Recorder for Remote Control by Radio, by F. W. Dunmore, Radio Laboratory, Bureau of Standards."

Mr. HUGHES. We object to it, if the court please, as immaterial. This is not a bureau publication, and it is not material to the issues

of the case. Here is a publication made by Dunmore in a commercial paper.

The COURT. Is the proof of the bureau directed to the publication of this article?

Mr. HOLTZOFF. The paper which has just been admitted in evidence shows that Mr. Dunmore asked the bureau's approval of this publication in this journal, because the journal is mentioned in that paper, and the publication was approved by Mr. Stratton, the director. If your honor will glance at the top of this paper, you will notice "To be published in A. I. E. E.," which is the journal in question.

The COURT. And that is the Journal of the American Institute of Electrical Engineers?

Mr. HOLTZOFF. Yes; that is what I have here.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Exception noted.

(Received in evidence and marked "Plaintiff's Exhibit No. 48.")

By Mr. HOLTZOFF:

Q. Dr. Dellinger, did you ever have any conversations with Mr. Lowell about any paper that might be prepared or published by him?

Mr. HUGHES. I object, if the court please. I do not see the relevancy.

The COURT. What is the objection?

Mr. HUGHES. It is immaterial.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

A. I recall that I had some dealings with Mr. Lowell in regard to papers to be published by him on his work, but I can not recall any specific conversations, nor be certain that they were direct conversations with him rather than arrangements through Mr. Whittemore or Mr. Ould, the publication assistant.

The WITNESS. I have here a paper certified to by the Secretary of Commerce, entitled "Editorial Record," and which bears the signature of Mr. P. D. Lowell, which is the editorial record sheet submitted for bureau approval, being a paper by Mr. Lowell entitled "Note on the Development of an Electron Tube Amplifier Using 60-cycle Alternating Current to Supply Power for the Filaments and Plates," to be published in the Journal of the American Institute of Electrical Engineers.

The COURT. That is similar to the other?

Mr. HOLTZOFF. Yes; I offer this paper in evidence.

Mr. HUGHES. This paper has nothing to do with the patents in suit or the invention. It is simply the routine matter of the bureau apparently, whereby a man wants something published. This is not binding in any way, or a recognition on the part of Lowell in any sense with respect to his patents. I think it is wholly immaterial, and burdening the record needlessly, by a document which is immaterial. I object to its admission.

The COURT. Is it an introduction of a publication that bears on the patent?

Mr. HOLTZOFF. Yes.

The COURT. On that ground it is admitted.

Mr. HUGHES. Exception.

The COURT. Exception noted.

(Received in evidence and marked "Plaintiff's Exhibit No. 49.")

The WITNESS. The signature at the head of the paper in the first block is the signature of E. C. Crittenden, chief or acting chief of the electrical division. The signature in about the middle of this sheet is a photostat of Mr. Lowell's original signature, and at the bottom of the sheet is the signature of F. C. Brown, who is indicated here as director but who may have been acting director.

The COURT. Is his official character indicated as director?

Mr. HOLTZOFF. Yes; his official character is indicated as director. May I show this paper to your honor?

The COURT. This is similar to the others?

Mr. HOLTZOFF. Yes, sir.

By Mr. HOLTZOFF:

Q. I show you a pamphlet entitled "Scientific Papers of the Bureau of Standards, No. 450, an Electron Tube Amplifier Using 60-Cycle Alternating Current to Supply Power for the Filaments and Plates," by P. D. Lowell, associate physicist, Bureau of Standards, dated October 2, 1922, and I ask you if this pamphlet is a publication of the Bureau of Standards?

A. Yes.

Mr. HOLTZOFF. I offer this pamphlet in evidence.

Mr. HUGHES. I object to it as immaterial.

The COURT. That is a publication of the bureau itself?

Mr. HOLTZOFF. Yes, your honor.

The COURT. And contains an article by Mr. Lowell?

Mr. HOLTZOFF. Yes, sir; the article referred to in the editorial record sheet which your honor has in your hands.

The COURT. And the article itself referring to something patented in this case?

Mr. HOLTZOFF. Yes; the article refers to the alternating-current receiving set which is covered by one of the patents.

The COURT. Admitted.

Mr. HUGHES. Exception. My point is, of course, that that paper is immaterial and does not bind the inventor. It is not any admission against the inventor and can have no probative force on the issues of this case. May I have an exception to your honor's ruling?

The COURT. I think it does indicate a certain admission of interest and ownership on the part of the United States in the matter, and it has probative value to that extent, in my opinion. It is admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 50.")

By Mr. HOLTZOFF:

Q. Did you at any time have any conferences or conversations with Mr. Lowell or Mr. Dunmore, or both of them, in reference to any patents that might be applied for or obtained on developments made by them at the bureau?

Mr. HUGHES. We object. The question might be a proper one if it was restricted to the patent in suit, but we are not interested in any other patent.

Mr. HOLTZOFF. I am willing to accept that amendment. I will limit my question to any patent that might be obtained on the development consisting of either the radio relay or the alternating current receiving set or loud speaker.

A. Yes; I had a conversation in 1922 in regard to the taking out of a patent through bureau channels dedicated to the public on alternating current amplifier development with Mr. Lowell, and subsequently one or more conversations with Mr. Dunmore.

The WITNESS. The time of these conversations was probably in June, or about June, and it was after the completion of this development of the alternating current supply amplifier and was subsequent to conversations which I had with the director, one or a few days before, in regard to the subject of patents on these devices.

Q. State what transpired in the various conversations with Mr. Lowell and Mr. Dunmore.

Mr. HUGHES. I object, if the court please. The conversations to which Dr. Dellinger refers were subsequent to the application of the patents, and it is wholly immaterial what was said or done after that time. The patents were applied for in March. The conversations referred to were in June.

The COURT. I do not see that that matters. I think the conversations are pertinent. The objection is overruled.

Mr. HUGHES. Exception, please.

A. I told Mr. Lowell that the director desired that a patent or patents be taken out——

Mr. HUGHES. I ask that that be stricken out.

By the COURT:

Q. Was this a conversation with the director?

A. With Mr. Lowell.

Q. Will you state that again, please? I could not hear it.

A. I told Mr. Lowell that the director desired that a patent or patents be taken out——

The COURT. Do you object to this, Mr. Hughes?

Mr. HUGHES. I do.

The COURT. The objection is overruled.

Mr. HUGHES. Exception, please.

A. (Continued.) On the alternating-current development. Mr. Lowell told me that this would be impossible, because a patent had already been applied for privately. I don't remember any further details of the conversation.

By Mr. HOLTZOFF:

Q. When was the next conversation with either one of these gentlemen, or both?

A. Within a period of a few days, I should say certainly within two weeks, I discussed this matter with Mr. Dunmore, and I asked Mr. Dunmore something further about the circumstances of the patent, including the question as to why this was done without informing the bureau. Mr. Dunmore told me that he knew if it were applied through bureau channels, a dedication to the public would be required, and that was the reason that they took the course they did.

Then there was a conference in my office between the director, Mr. Whittemore, Mr. Dunmore, Mr. Lowell, and I believe one or two others. This conversation took place also within some such period as two weeks after the first conversation I mentioned with Mr. Lowell. The director expressed himself very vigorously in disapproval of the course which had been taken.

Mr. HUGHES. I object, if the court please. We are not interested in how vigorously the director expressed himself. If the director wants to express himself, let him come down here and do it. Dr. Dellinger can testify to how vigorously he expressed himself, but he cannot testify as to how vigorously someone else did.

The COURT. The objection is overruled.

Mr. HUGHES. Exception, please.

The COURT. Let an exception be entered.

The WITNESS. The next conversation of which I have any recollection is a meeting in the office of Mr. Knight of the Department of Justice. This could not be exactly called a conversation, as it was a somewhat more formal procedure. Do you wish me to describe that?

By Mr. HOLTZOFF:

Q. Yes. State what transpired. Were either Mr. Lowell or Mr. Dunmore present?

A. Yes.

Q. State what transpired on that occasion?

A. The occasion was a formal demand on the part of the Government that all rights in connection with these patents be turned over to the Government. Mr. Knight, representing the Department of Justice, made this demand. Mr. Lowell and Mr. Dunmore were present with attorneys representing them. In the course of this meeting, these gentlemen again made the admission that they had taken out patents——

Mr. HUGHES. I object, if the court please.

The COURT. "These gentlemen" refer to Mr. Lowell and Mr. Dunmore?

Mr. HUGHES. It is a pure conclusion as to what an admission is. The plaintiff in a case of this sort is not entitled, I think, to the presumptions of conclusions of law expressed in colloquial English. He is not stating what they said, but he is stating a conclusion of what they said. That is my objection.

The COURT. The objection is overruled.

Mr. HUGHES. Exception, please.

The COURT. Let an exception be noted.

The WITNESS. In the course of the meeting, I have a clear recollection that an admission was made by Mr. Lowell, or Mr. Dunmore, or both, that the patent had been applied for without informing the bureau because they knew that if they went through that channel a dedication to the public would be required.

By Mr. HOLTZOFF:

Q. Did they reply to the demand that the applications or the patents be assigned to the United States?

A. Their reply to the demand for either assignment or the equivalent thereof was a refusal.

Mr. HOLTZOFF. You may cross-examine.

(Before cross-examining J. H. Dellinger, the testimony of Laurens E. Whittemore was taken at this time, as he had to leave town this afternoon.)

LAURENS E. WHITTEMORE, having been duly sworn, was examined and testified as follows:

Direct examination:

From 1917 until some time in 1924, I was a physicist in the radio laboratory of the Bureau of Standards. During the major part of

the time, the latter part particularly, I was alternate chief of the radio section, and I held such position during the years 1921 and 1922.

My duties as alternate chief of the radio section were to assist the chief of the section, Dr. Dellinger, in the general administration of the work of the section and particularly to attend to matters relating to office management, some equipment matters, personnel, and various miscellaneous points which might facilitate the general work of the section.

I terminated my connection with the Bureau of Standards early in 1924, when I went with the Department of Commerce. Perhaps I went there a little before that, in 1923, to serve as secretary of the Interdepartment Radio Advisory Committee, a Government committee on radio matters, and I was with the Department of Commerce in that capacity until the close of 1924.

These were the only formal positions I held with the Government. On the other hand, there were various conferences, namely, national radio conferences, called by the Secretary of Commerce, of which I was secretary or assistant secretary. At that time, Mr. Hoover, who was then the Secretary of Commerce, was the chairman of these conferences.

At the present time I am employed by the American Telephone & Telegraph Company as an engineer in its department of development and research.

By Mr. HOLTZOFF:

Q. Referring back to the spring of 1921, do you remember participating in any conferences or discussions relating to the proposed program of research to be performed by the radio section of the Bureau of Standards for the Air Service of the Army?

A. Yes; there were several conferences. As I recall, there was one in the latter part of 1920 and that was one at which Lieutenant Van Zandt, of the Air Service, came to the bureau and talked with some of us about work that the Air Service was interested in on which the Bureau of Standards might engage and there were other conferences subsequent to that time during the following year.

Mr. HUGHES. I move that the answer be stricken out if the court please. There is no authority shown for the Bureau of Standards participation in any such conference, if conference there was.

The COURT. That objection is similar to other objections of like sort. The objection is overruled.

Mr. HUGHES. Exception, please.

The COURT. Let an exception be noted.

By Mr. HOLTZOFF:

Q. Subsequently to those conferences did you prepare a memorandum or a list of radio problems upon which the Bureau of Standards might be of assistance to the Air Service?

A. Yes, sir. I remember the Director of the Bureau of Standards asked for some information as to particular projects or lines of work that the radio laboratory or section of the bureau was in a position to engage in, which might be of interest to the Air Service. A memorandum outlining a number of such projects was prepared.

Q. I ask you if this is a carbon copy of this memorandum prepared by you?

A. Yes; it is a copy of a memorandum dated May 2, 1921, entitled "Radio Research Problems Suggested to the Air Service" and bears my initials typed in the corner of the memorandum.

Mr. HOLTZOFF. I offer this memorandum in evidence.

Mr. HUGHES. I object to it if the court please. The document is immaterial. It is admittedly only a carbon copy and it has no probative force binding on the defendants in this case.

The COURT. Have you brought out the source? Where is that taken from?

Mr. HOLTZOFF. It is taken from the files of the Bureau of Standards.

The COURT. Is that understood?

Mr. HUGHES. No; it is a carbon copy of something and I do not know where it is taken from.

By Mr. HOLTZOFF:

Q. Do you know whether this document is taken from the files of the Bureau of Standards?

A. I assume that it is. It bears a few pencil notes in my handwriting which were made at the time this memorandum was prepared or within a day or so of it as a part of the radio laboratory work there at the Bureau of Standards.

Q. And you caused it to be filed in the office of the radio laboratory?

A. Yes. This memorandum or a similar carbon copy would be there as a part of the files in the Bureau of Standards.

The COURT. Now, as to its pertinency.

Mr. HOLTZOFF. This is along the same line as certain other memoranda that were introduced yesterday to show that this research work was done for the Air Service. It ties up with the proof that $267,000 was transferred by the Air Service to the Bureau of Standards for the purpose of being spent on certain research problems.

The COURT. Does it define the scope of the function of the bureau?

Mr. HOLTZOFF. It gives a list of problems that the bureau might work on or develop for the Air Service. It is part of the res gestae in that regard.

The COURT. Is it offered as defining the scope of the work of the bureau?

Mr. HOLTZOFF. It is offered for the purpose of showing—yes, I might say yes, because it is offered to show that the development of this radio relay was one of the things that the bureau undertook to do for the Air Service.

Mr. HUGHES. If the court please, of course, there is no effort to show that there is any authority for the bureau undertaking to do anything for the Air Service.

Mr. HOLTZOFF. That has been shown.

Mr. HUGHES. I do not remember how it has been shown. This is a memorandum not signed. Do you know that this was taken from the files of the radio laboratory?

The WITNESS. I do not know where that particular copy was taken from, but there was a memorandum of which that was a copy which was prepared at the time at the request of the Director of the Bureau of Standards.

The COURT. Prepared by yourself?

The WITNESS. Yes, and at that time the information was given to him for his use in discussing with the Air Service officers the work that the Bureau of Standards was in a position to do for the Air Service at that time in connection with the possible allotment of funds.

Mr. HUGHES. Here we have a carbon copy of something. It is not signed. It has L. E. W. at the left-hand corner and it might have been put there by anybody and no authority showing for its being made up, and there is no authority where that memorandum has been in the meantime and no authority showing that there was ever any legal power in the Bureau of Standards to undertake anything shown on there, and the paper is offered as having some probative effect for something, presumably connecting with some connection with the patents in suit here, or with the ownership of the patents in suit. It seems to me on all those grounds, in addition to the fact that it has no pertinency to the issue, that the paper is not admissible as offered.

The COURT. I understand the acting chief of the bureau, who is the witness, prepared this memorandum of which he says this is a copy; is that correct?

Mr. HOLTZOFF. That is correct.

The WITNESS. I was only the alternate chief of the radio section.

Mr. HUGHES. That is, alternate chief of one of nine or eleven or thirteen sections?

The COURT. Ten, I believe.

Mr. HUGHES. I think one witness said nine and then named eleven. However, a great many. That does not stamp it as any official document.

The COURT. We are concerned primarily with the function of the radio section, are we not?

Mr. HUGHES. Yes.

The COURT. And the witness, as I understand, is the acting chief.

The WITNESS. At that time.

The COURT. At that time. And this is a memorandum which he himself prepared more or less defining the functions of that section. For what it is worth I rule that it should be admitted.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

(Received in evidence and marked "Plaintiff's Exhibit No. 51.")

By Mr. HOLTZOFF:

Q. Can you state what steps were taken in the spring and summer of 1921 in connection with carrying the Air Service program into execution?

A. Yes; after the allotment of funds was made to the bureau, and the several projects in which the Air Service was definitely interested were specified, steps were taken to have certain persons on the bureau staff work on those particular jobs more accurately, and carry on research and development work along the lines particularly designated by the Air Service.

Mr. HUGHES. I move that the last part of the answer be stricken out, if the court please, as not responsive to the question. The witness was asked, "Can you state something?" The witness said, "Yes." That was his answer. Then he rambled on to something that is not responsive.

The COURT. Objection overruled.

Mr. HUGHES. Exception, please.

The COURT. Let an exception be entered.

The WITNESS. I prepared the list of radio projects for the United States Air Service dated July 29, 1921, which has been marked "Plaintiff's Exhibit No. 18." This list of projects contains not only the actual title of each project, but an outline of the work to be done under each project, both in Washington, D. C., and in Dayton, Ohio. That was prepared by me at that time.

I had conversations or conferences with Mr. Dunmore in reference to some of these projects. They were held at the time of the proposed and actual allotment of funds from the Air Service to the bureau for this work, and at times following that, which was in the fall of 1920 and during 1921.

As I recall, the allotment of funds was made to the bureau perhaps late in the spring or early in the summer. I can not remember the details of what took place at these conversations other than that they involved the discussion of the kind of research and development work that would be required and the way in which certain work which had previously been in progress at the Bureau of Standards could be made useful and used as a basis for further research and development on these particular projects.

I remember a specific project mentioned or discussed in these conversations with Mr. Dunmore.

It was the project which related to airship bomb control, which would involve the use of a relay device. There were other projects relating to direction finding, visual indications, and other matters which involved the sort of work that was being done and could readily be done in the Bureau of Standards radio laboratory.

At that time Mr. Dunmore's position was that of one of the men in charge of a certain class of work. Each of the men in charge of special groups or classes of work like that were called group chiefs. Mr. Dunmore was one of them.

The work assigned to the group of which Mr. Dunmore was chief was mainly along the line of direction finding and apparatus development, which fell in directly with this Air Service type of project. As I recall, the remote-control project was assigned to the same group.

Looking at the papers which have been marked in evidence as Plaintiff's Exhibits Nos. 11, 12, and 15, one of which is the radio laboratory outline of July 29, 1921, the second being a similar outline dated October 3, 1921, and the last being a guide to the radio laboratory, dated February 23, 1921, all of which bear my initials, I can testify that I prepared these papers.

I am acquainted with Percival D. Lowell. He was employed at the radio laboratory of the Bureau of Standards at the time in reference to which I am testifying. He was a member of the technical staff of the radio laboratory.

I remember seeing the relay that Mr. Dunmore worked on in the Bureau of Standards. I can not fix the time definitely, but in the course of our work there in the bureau, there were various occasions on which I would be in the different rooms where the different men in the laboratory were working, and I was shown the apparatus that was in use or in the course of development from time to time, including this relay device.

I remember one occasion when the relay arrangement was being used for the reception of time signals, one point of interest being the possible adaptation of that sort of device to the setting of a clock.

I am not sure whether it was Mr. Dunmore or Mr. Lowell who exhibited and demonstrated that device to me. It was undoubtedly one or the other. This was done at the time this work was in active development. I would say it was some time in 1921; it might possibly have been in 1922.

It is hard for me now to tell the actual time or date that this work was going on, that is, if it were in 1922 whether it was early or late in the year. Work of that sort was going on at the time when we were also carrying on some studies of radio receiving sets because of the interest of the Department of Agriculture in that work. That work, I remember definitely, was in the summer of 1921.

The relay project was being developed at about the same time; in fact, all of these projects on the Air Service list were in progress at that time.

As I remember, there was an occasion when Mr. Lowell or Mr. Dunmore showed me one of these alternating current receiving sets that we were working on in the interest of the Department of Agriculture. The men in the laboratory connected up the alternating current supply arrangement in such a way that the receiving set was getting its power from the alternating current supply and was operating that way.

As to the time, I think that probably was in the latter part of 1921, although I am not sure. I know I had more than one occasion to see this alternating-current receiving set; in fact, I saw it many times. This particularly applied in relation to the Department of Agriculture's interest in receiving sets. As I recall, it was set up in the room in which Mr. Preston was working, although most of Mr. Dunmore's and Mr. Lowell's work was done at the other end of the laboratory, in a larger room where their work was carried on. My recollection as to this set and its connection with the Department of Agriculture's receiving set—although possibly it was in connection with the loud speaker connected to the set, I am not entirely clear as to that point—but as I remember it was in a room toward the northern end of the building in the direction away from that where Mr. Lowell and Mr. Dunmore usually worked. Their room was in the eastern end of the building. I said "north" just now when I should have said "west."

I note that this apparatus was operated by alternating current because they plugged the power-supply lead from the set right into the lighting circuit. Of course, there was some discussion and some remarks about it at the time.

By the COURT:

Q. Into the light circuit?

A. Into the lighting circuit, the power supply of the building.

Cross-examination:

The airship-bomb control to which I have referred was the name of one of the projects that the Air Service was interested in having the bureau work on or having work done on it that was helpful. Beyond the name of the project the Air Service was interested in having some remote-control arrangement by which a bomb carried by an airship might be released. The control was to be back at the radio transmitting station on the ground, the signals being received on the plane and actuating some device to control the release of the bomb. The relay type of device is the sort of thing that would be useful in accomplishing that function. The relay was to be placed on the airplane. It would be placed where the signal would operate the relay.

Since I have never seen a relay device operate I am afraid I can not describe what are the steps after the signal reaches the receiving set to effect this bomb control. However, the use of a relay-type device is rather obviously the sort of thing one would need.

I have never seen a bomb control and I am not familiar enough with an airplane to state what power was there to operate the receiving set. I can not say as to what kind of power there was to operate the relay. Airplanes may be equipped with power devices either from batteries or from generators driven by the wind. As to what kind of power was in use upon a particular plane I am unable to say.

I do not know that any member of the staff tried a bomb control in an airplane. As to the usual type of power on the airplane to run the receiving set at that time, I am afraid I am not qualified to answer. Mr. Dunmore, and others who were working on that particular line of work, was studying the problem in more detail. As to the particular kind of power that they had to use on airplanes, as I said before, it was ordinary storage batteries or wind-driven generators, and that was my understanding of the situation. The storage batteries that would be employed on an airplane to operate the receiving apparatus would be those that might be purchased and installed on the plane. There also might be wind-driven generators to operate the receiving set. The kind of generators I mean are those operated by a wind-driven propeller.

I presume such a device—the generator—would be used to operate either a transmitter or receiver. I am not familiar with the details as to just how those sets were handled, to answer your question intelligently. As to the character of the current coming out of the generators, I would presume that it would be whatever would be necessary to operate the set on the plane. I presume in many cases it was direct current. Perhaps always. I do not know.

This card you handed me is a photostat copy of a weekly report card which I prepared covering the week December 12 to December 17, 1921; the original card of which this is a photostat is in my handwriting.

The item on this card in line 5 thereof "Cf"—an abbreviation for conferred—"FWD and Major Young re patent on relay." That is an item regarding the conversation held some time during that week covered by this record. I did not say I had no record of that—I believe you misunderstood me; I said during the week covered by this record, meaning this weekly report card.

FWD was Mr. Dunmore. Major Young, as I recall, was an officer of the Army Air Service.

This notation purported to cover a conversation which must have been held at that time on that subject, though I must say I do not recall the conversation at all. I have no recollection of it.

Mr. BRADY. I ask that the card referred to by the witness be marked for identification.

(Received and marked "Defendant's Exhibit A for Identification.")

The WITNESS. I might supplement my statement about that and in looking up that card further, it occurs to me that that refers to separate talks with Mr. Dunmore and Major Young. It may be that I talked with Major Young on the telephone at or about the time of talking with Mr. Dunmore. I do not remember any conference on that subject and that is the only further point that occurs to me about that.

JOHN H. DELLINGER resumes the stand and testifies further as follows:

Cross-examination:

The radio section of the Bureau of Standards was organized as a single section about 1917. Prior to its unification as a single section about 1917, the radio work had been divided into a number of groups which, as I recall, did not have specific names, dating back to 1911 or 1912. The several groups as I recall were in charge of Mr. F. A. Kolster, Mr. J. M. Miller, and myself.

Mr. Kolster left the Bureau of Standards around February 1, 1921. Prior to his leaving, for a period of something like two years, the radio section was in two branches. The branch of which Mr. Kolster was the chief was called section 6–B, and was devoted to what we called radio development.

During the years 1917 and 1919 Mr. Kolster was a senior in that section over me. During the period 1919 and following that he was not.

To my knowledge, the Bureau of Standards did not have any written contract with Mr. Lowell or Mr. Dunmore with respect to the assignment of patents for inventions discovered by them while in the employ of the Bureau of Standards.

To the best of my recollection, the conferences in 1921 with the Air Corps of the Army were in general instituted by the particular officers of the Air Corps who participated in them.

I do not recall that at the close of the war the Bureau of Standards found itself with a number of technicians without much work; in fact, I do not recall any period when we could describe the condition of the bureau as finding itself without much work.

I do not recall who was present at the conferences with the Air Corps when the projects were discussed which are described in the memorandum of July 29, 1921, plaintiff's Exhibit 18. I was a participant in a conference with Lieut. Van Zandt some time within a few months prior to this memorandum. My recollection of that conference is that it was a discussion of both work which had been done and work which might be done in the future, somewhat expanding what we had been doing for the Air Service. I do not remember whether it went down to the mention of the specific problems and therefore I can not say that I remember being present at any conferences with Air Corps representatives where these particular projects were discussed.

Yes, I can see some cases where some work was done on these projects in the Bureau of Standards in the radio section before the compilation of this outline of radio projects for the United States Air Service, dated July 29, 1921, which appears to contain certain defined projects.

I do not know whether any work was done on project 38 and project 42 before the compilation of that outline.

I spent the summer of 1921 in Paris. I left the bureau about the first of June to go abroad, and I returned around the first of October.

When the Bureau of Standards undertook work for the War Department or the Navy Department the projects in contemplation were decided upon before the work was started. I can not think of any cases where the contrary was true.

The projects appearing on the memorandum of July 29, 1921, Plaintiff's Exhibit No. 18, were formally approved by the Air Service and by the Bureau of Standards prior to the compilation of this outline. It is my recollection that the list of projects had been formally approved by both the bureau and the Air Service.

I can not say that there had been any assignment of project 42, which appears on this outline, prior to the compilation of it. However, I would say in clarification that on a number of these projects

and other pieces of work which we did for the military departments we frequently made use of devices or developments which had been brought to some progress of completion for other purposes and adapted them to the purposes of the other departments, so in that sense there may have been work done prior to the compilation of this outline, but as to specific assignment of it before I do not know.

No; I can not say that project 42 was given assignment in my section prior to the compilation of this outline. I think I stated in my testimony this project was assigned to Mr. Dunmore; that is right. I can not say that I made the assignment; I do not recall.

The first line of project 42 is a description or title of the problem. In stating just what was desired in problem 42 I would like to draw this distinction: As to the military problem referred to, we in the bureau had no specific knowledge of the military device itself. The particular element of the military device or system upon which assistance was desired was the radio portion of it. The part of that on which it seemed that the bureau might most reasonably contribute something was the specialized portion of the radio system which gave the system the ability to operate control mechanisms on the plane. That is to say, radio receiving apparatus simply to receive a radio signal was fairly standard. The Army had it.

; they did not have it in the Eckhardt relay. I am not speaking of a relay device, but just a receiving set. To operate a bomb control or a similar device, it was necessary to have a receiving set which would be as free as possible from interference, and therefore it seemed that any contributions we might make in that connection would be helpful, and the construction or furnishing of a device which would serve the function of the relay which when connected to the receiving set in turn operated controls of some kind also seemed to be a part of the thing in which the bureau could be of assistance.

The Air Service wanted—taking this for a homely illustration—a device which by pushing a button in the dugout an officer could control some mechanism on the airplane 5 miles away, which had no pilot in it, and by that control release a trigger which would drop a bomb.

The notations under the caption sentence of project 42 are particular lines of work under this general heading which Mr. Whittemore indicated as useful lines to pursue.

Q. Now, Dr. Dellinger, I want to ask you a very simple question: Was there any house lighting connection on an airplane?

A. No.

Q. There was no device on an airplane for the use of alternating current, was there, the 60-cycle house-lighting current?

A. I am not perfectly informed as to what the power supplies on airplanes were, but it is my general belief that the power supply on practically all, if not all, airplanes was direct current and not alternating current.

Q. When the projects for the Air Service experts were discussed did they make any mention of the use of an alternating-current relay for this bomb-dropping device?

A. Not to my knowledge.

Q. When project 38 was discussed with the Air Service experts, was the application of alternating current to the device there contemplated, discussed with the Army men?

A. Not to my knowledge.

Q. I take it that the problem in 38, the visual indicator for radio signals, had some such purpose as this:

A man might control his airplane and might be signaled to from the ground by something similar to dashboard apparatus on an automobile?

A. By something similar to what?

Q. To a dashboard on an automobile, where you simply look down, without getting out, and without having to go to the back to see how much gas you have, for instance?

A. Yes.

Q. Was there any device on an airplane for the application of house-lighting current to such an indicator?

A. Not to my knowledge.

Q. Dr. Dellinger, did you ever discuss with Mr. Dunmore the application of house-lighting current in the solution of project 42 when he first began working on it?

A. I do not have a clear enough memory of the circumstances of those times to state.

Q. Did you have any such discussion with Mr. Dunmore on any work that he may have done with respect to the visual indicator for the radio signal problem?

A. I don't remember.

Q. In your opinion, Dr. Dellinger, would project 42 have been satisfactorily solved with the use of batteries generating direct current?

A. Yes.

Q. You have testified to two types of relay, an A relay and a B relay; the A relay energized by direct current, and B relay by alternating current; is that correct?

A. Yes.

Q. You saw the A relay, did you not?

A. Yes.

Q. The A relay solved the airplane bombing control problem No. 42 undertaken by the bureau for the Air Service? Let me explain my question. I do not mean whether they accepted it and said: "This is a howling success." But would it work for the purpose for which it was designed?

A. I should say in a general way, yes.

Q. Did you know Mr. Eckhardt of the Eckhardt relay?

A. Yes.

Q. This question is a bit general, but I do not know much about it myself: That was a direct current relay, was it not?

A. I do not recall anything about the Eckhardt relay.

Q. Do you know whether or not the Air Service was using an Eckhardt relay for this general purpose, the bomb control, when they came to the Bureau of Standards?

A. No; I do not.

Q. You do not know anything about it?

A. No.

When I returned from Europe at the end of September I proceeded to make up the reports of my continental trip and conferences there. I have no definite recollection of how much time they took. It may have been an appreciable time. I should say something on the order of a few days.

I don't know when I first saw Mr. Dunmore after my return from Europe. I couldn't say it was the same day, as I have no particular recollection of that. If you care for me to particularize, I might say it might have been several weeks until I did so, but not several months; that is, it might have been more than a few days.

Q. Do you know when Dunmore accomplished or completed the Breadboard model of the type A relay?

A. No; I do not.

Q. You do not know whether that was done when you returned or not, do you?

A. No.

Q. Did you offer him any suggestions as to the construction of the type A relay upon your return from Europe?

A. Not that I remember.

Q. Did you ever at any time offer him any instructions, assistance, or suggestions as to the working out of the B relay?

A. I can only say that I remember talking with him about the relay in its applications and the nature of the work, but whether any of those conversations included the assistance, suggestions, and so forth, which you mention I do not know.

I do not have the relay-circuit arrangement and similar arrangements that might have been developed before in mind sufficiently

well to give an answer to your question as to whether there was anything new in that instrument; that is, as to whether it was a patentable device or whether there was any invention in it—the A relay—or whether it was a mere set-up of mechanical arrangements already known in the art, or rearrangements, or readjustments.

Q. So far as the airplane-bomb control problem was concerned, first, that project did not necessarily contemplate an invention for its achievement, did it?

A. I should say not necessarily.

Q. It might as well have been accomplished by a different arrangement of, we will say, coils and condensers and what goes to make up a relay on, we will say, the Eckhardt relay?

A. Yes.

Q. That would be a mere mechanical arrangement?

A. I should think it might be.

With reference to the conversations that were had in the bureau at which Messrs. Lowell and Dunmore were present, with respect to the application of alternating current to radio devices, I can only remember in a general way that the more responsible men of the section, such as Mr. Whittemore, Mr. Preston, Mr. Ould, and myself, together with Dunmore and Lowell, had conversations on this subject, but how many of them were present or whether others were present at any particular times I can not say.

Q. When were these conversations, do you recall?

A. During one or more months prior to January, 1922, when the assignment of work specifically of time on the project was made.

Q. Might it have been in December, 1921?

A. Yes.

Q. What part of December?

A. I have no idea.

Q. It could not have been the last part, could it?

A. My memory is too vague to give any indication on that point. I am sorry.

These two sheets of paper I have are weekly reports of my own from December 12 to December 17, 1921, and from December 19 to December 31, 1921, giving a little information of my work done and also mentioning leave, sick leave, from December 13 to 17, and other leave from December 20 to the 31st.

Mr. HUGHES. I ask that these two sheets be marked for identification.

(The same was thereupon marked, respectively, "Defendant's Exhibits B and C" for identification.)

Q. Then you could not have had these conversations between December 13 to the first of January?

A. I think not.

Q. You were out of the office?

A. Yes.

Q. How many times did you see Mr. Lowell during the months of November and December, 1921?

A. I do not remember.

Q. Do you know what work he was doing during that time?

A. No.

Q. Do you not know that he was out of the bureau for most of these two months on field work for some branch of the Air Service, or don't you know that?

A. No.

Q. You do not know whether or not he might have been at Bolling Field in connection with radio-compass work a large part of November and December?

A. I do not know that, but he might have been.

Q. When did it come to your attention, and I would like you to be specific on this, please, that Mr. Lowell and Mr. Dunmore were working on an alternating current receiving set? I am not speaking of the relay now or of the loud-speaker, but of the receiving set?

A. I think that it did not come to my attention that Mr. Lowell was doing any work on alternating current receiving sets prior to early in January, 1922.

Q. And Dunmore?

A. And as to Dunmore I have the impression that shortly prior to the definite assignment of Lowell to this work in early January, 1922, it came to my attention that Dunmore had been doing something more or less in connection with his work on the alternating-current relay that indicated applications to the use of the alternating current on the receiving set, but whether that was to the effect that he had actually done work on such a receiving set or had merely gotten indications from his work on the relay that it would be feasible, I do not know.

Q. Do you know or do you recall just how that came to your attention?

A. No; except that it seems to me that it was in connection with these conversations among the several of us in the section.

Q. And at whose request was the Lowell memorandum of January 9th prepared?

A. As I recall, that was prepared at my request.

Q. Do you recall what gave rise to that request on your part?

A. I recall it, in general, as follows: It became more evident in the conversations that we had in the section about the desirability of work on an alternating current amplifier development that Mr.

Lowell and Mr. Dunmore were both very anxious to be assigned to work on it——

Q. Doctor, will you just explain that: How was that evidenced to you?

The COURT. Had you completed your answer?

The WITNESS. No; I had not.

Mr. HUGHES. I beg your pardon. Go right ahead.

A. (Continued.) And my reaction to their desire was to a considerable extent that they were both needed on other work. Subsequent to this first reaction on my part, in view of representations from some of the other members of the section, and further thought, it seemed to me desirable for Lowell to put a part of his time on this work and a part of his time on the other work, which I was more anxious for him to go ahead with, and in consequence of that, I asked that he prepare an outline which would indicate how he felt he might go ahead and carry on work on both jobs.

Q. Now, how did he convey to you his desire to work on this problem?

A. I don't recall specifically.

Q. Was it in writing?

A. I don't think so.

Q. Then it must have been in speech?

A. I think so.

Q. Now, just when, Doctor, if you recall, did you see Lowell with respect to the A. C. work?

A. I don't recall.

Q. Do you know why Dunmore was not assigned to that work?

A. Why he was not assigned to it?

Q. Yes.

A. Yes; because I felt that his time was needed on other projects, and as I recall particularly because we were obligated to do work for the Air Service, and Mr. Dunmore was the group chief in charge of that group of problems, and I felt that his time should go on work more nearly directed to that end.

Q. Now, Doctor, do you know when Mr. Dunmore completed his type B relay, the alternating-current relay?

A. Well, the process of completion, perhaps, was rather gradual. It seems to me that it was.

Q. Well, what I have in mind is this:

Do you know when he had completed the device? I am not speaking of when he had boxed it but when he had his relays working and his circuits working. Do you know that?

A. I have the impression it was in the latter part of 1921.

Q. Do you know what work Lowell and Dunmore had done on the A. C. receiving set in 1921?

A. I don't recall that Lowell had done anything on it in 1921. As I said before, I recall that Dunmore had done certain things in connection with either finishing up or working on the type B relay, which indicated the possibility of using some of the same ideas or methods for the amplifier.

Q. Do you now know, Doctor, when the A. C. receiving-set circuits were made to work by these men, Lowell and Dunmore? Again I am not speaking of the boxed apparatus. I am speaking of the board model where the hook-up is complete.

A. I think it would be proper for me to say that I now know that was accomplished in January or February, 1922, in view of my hearing this morning certain reports of theirs read which indicated that.

Q. Under what project was Lowell's assignment to the A. C. receiving set?

A. It was under a research authorization. The work of the bureau along research lines is governed by what we call research authorizations, which are different from the Air Corps projects.

Q. What I want to know is this: Was that an Air Corps project?

A. No.

Q. Was it paid for from Air Corps funds?

A. We are speaking about the amplifier development now and not the relay?

Q. Not the A or B relay.

A. No; this was not covered by Air Corps funds.

Q. When did you discover that Lowell was working on an electrodynamic loud speaker?

A. My memory is extremely vague on it, other than the information which I recently got from hearing the report cards read. I think I could only have said that it was some time during the first four months of 1922.

Q. Did you assign him to do that?

A. I assigned him to do that in the sense that the assignment to the amplifier job, as our assignments to all jobs, included offshoots; but as to a direct assignment, I did not.

Mr. HUGHES. I ask that the first part of the doctor's answer there be stricken out as not responsive. The last part was responsive.

Q. You did not assign him specifically to that task?

The COURT. Are you passing your objection?

Mr. HUGHES. I would like to have the first part of his reply to my question stricken out as not responsive.

The COURT. The ruling is that it should not be done. The answer will stand.

Mr. HUGHES. May I have an exception?

The COURT. An exception will be noted.

Q. You made no specific assignment of Lowell to that task?

A. Not that I recall.

Q. Have you any record that you made any such specific assignment, Doctor?

A. Not that I know of.

Q. How far had Lowell gone with that device when you found he was working at it?

A. My memory is almost a blank on that. I can not say.

Q. Did you make any technical suggestions to Lowell with respect to the loud speaker?

A. I think not.

Q. In your direct examination you said that you approved of the loud speaker. You did make such a statement, did you not?

A. I think I did.

Q. By that you mean that having found Lowell well along in that work you thought it was a good thing; is that right?

A. I think that is a substantially accurate picture of the thing, as far as my recollection goes.

Q. Was Dunmore assigned to the receiving set work?

A. Dunmore was not assigned to the receiving set work, except in so far as members of the laboratory were expected to assist and cooperate with other people on their work. In other words, general cooperation could be considered as his general assignment. But there was no specific assignment. In fact, I directed him not to spend his time on this work.

The COURT. Is this a convenient point to suspend for five minutes?

Mr. HUGHES. Yes, your honor.

The COURT. Then the court will recess for five minutes.

(After a short recess.)

By Mr. HUGHES:

Q. Dr. Dellinger, I show you time card of F. W. Dunmore, December 5th to December 10, 1921. The second line under date of December 5th, and this is one of the plaintiff's exhibits; will you please read that line?

A. "Went down to Air Service patent section regarding patent on receiving relay."

Q. That is the statement in F. W. Dunmore time card for December 5th, is it not?

A. Yes.

Q. Do you know to what that reference is, Dr. Dellinger?

A. It is fairly clear that it refers to the relay which Mr. Dunmore had developed.

Q. Did you know of his trip down to the patent section of the Air Service?

A. I do not recall the circumstances at all.

Q. Was it done with your permission?

A. I do not know, because I fail to remember it completely.

Q. Doctor, I will ask you to examine F. W. Dunmore's time card from November 21st to November 26, 1921, as of November 23rd. Will you read that entry?

A. "Worked recorder again for further demonstration of the radio typewriter before Navy officials."

Mr. HOLTZOFF. What date was that?

Mr. HUGHES. November 23rd.

By Mr. HUGHES:

Q. Did you attend that demonstration, Doctor?

A. I think not.

Q. Did you know anything about it?

A. I have no definite recollection of it.

As to the personal contact I had with the technicians in my section, I can say that I had a pretty extensive personal contact with the group chiefs. I mean that ordinarily I would have occasion to discuss matters with them, in some cases every day, and in some cases it might run a week or more. Taking such a man as Lowell and some other members of the section, I might not actually see and talk with them for a month or more, depending on the interest in the job they were handling, or circumstances, however, I might see and talk with them every day or two.

This group of papers you handed me, which are certified to by the Acting Secretary of Commerce, are a number of my own weekly report cards which appear to be for periods in the years 1921, 1922, and 1923. I do not know whether there are any entries on those cards with respect to the B relay of Dunmore.

I referred, in my direct examination, to a meeting in the summer of 1922 in the Department of Justice, attended by Mr. Dunmore, Mr. Lowell, and myself. Mr. Knight, representing the Department of Justice, and two or more lawyers, representing Mr. Dunmore and Mr. Lowell, were also there. The lawyers representing Mr. Dunmore and Mr. Lowell were Mr. Brady and, I think, Mr. Shoemaker.

It is my recollection that the talking for Mr. Dunmore and Mr. Lowell was done largely by their lawyers and in part by themselves. I do not know whether or not Major Walter W. Burns was present at that conference.

As to whether Mr. Lowell and Mr. Dunmore tendered a license to the Government for patent No. 1455141, the receiving set patent, I recall there was some department correspondence which did include

the tendering of such a license. Answering your question as to where that license is now, I must answer that I do not believe the license exists, if I understand the word "license" correctly. A license was tendered but not consummated. I do not know where the paper is that was tendered to the Government, but I suppose it is in the files of the department. It might be in the files of the Department of Commerce. The Department of Justice has been interesting itself in many of the papers relating to this case and might have it. As to whether it might be in the War Department, it is possible that it might be. I do not know where the paper is. I know that it was in the files of the Department of Commerce and of the Bureau of Standards.

These papers you have handed me, which are certified to by the Secretary of Commerce, are a number of copies of appointment certificates, of a type which are given to each new employee at the bureau telling him formally of his appointment, and I believe some of them, or perhaps all of them, may also be similar certificates which are given when a man is promoted.

Mr. HUGHES. I want to offer for identification the general appointment card and promotion cards of Frederick A. Kolster.

Mr. HOLTZOFF. We can stipulate that he was employed in the bureau if that will help you any. I do not know what the object of this is, but if there was any question as to whether he was an employee of the bureau, I will stipulate that he was.

Mr. HUGHES. It is understood and admitted by the plaintiff that Dr. Kolster was employed in the bureau.

The COURT. When?

Mr. HUGHES. I will ask the witness that.

By Mr. HUGHES:

Q. What was the term of Mr. Kolster's appointment?

Mr. HOLTZOFF. We can stipulate that from these certificates.

Mr. HUGHES. From November 29, 1911.

The COURT. And in what capacity?

Mr. HOLTZOFF. I will stipulate the capacity if Mr. Hughes wishes me to. He was employed as a physicist.

Mr. HUGHES. And as a chief of one of the two branches of the radio section before its unification in 1921.

Mr. HOLTZOFF. That is not disputed.

By Mr. HUGHES:

Q. When did Mr. Kolster leave the Bureau of Standards?

A. It is my recollection that he left about the first of February, 1921.

Q. Dr. Dellinger, will you examine this paper?

The WITNESS. This paper is a copy of Scientific Paper No. 428 of the Bureau of Standards, entitled "The Radio Direction Finder and its Application to Navigation, by F. A. Kolster and F. W. Dunmore."

Mr. HUGHES. I ask that this be marked for identification, if the court please.

(The same was marked "Defendant's Exhibit D for identification.")

By Mr. HUGHES:

Q. Dr. Dellinger, I hand you a number of documents which are patents issued to Mr. Kolster. Will you examine those briefly, please [handing patents to witness]?

A. (Witness examines patents.)

Q. Now, Doctor, will you again look at this exhibit and tell us whether the matters covered in that scientific paper issued by the Bureau of Standards cover the claims in the patents which you have just examined, issued to Dr. Kolster? That is a rather large question, but take your time.

Mr. HOLTZOFF. Are you making Dr. Dellinger your own witness?

Mr. HUGHES. No.

Mr. HOLTZOFF. Then I object to it as not proper cross-examination. I do not object to the question if it is understood that by this question Dr. Dellinger becomes the defendant's witness. It is not proper cross-examination, because it does not relate to any matter that Dr. Dellinger testified to on direct, nor does it go to his credibility.

Mr. HUGHES. I am not attacking his credibility. I have no doubt of his credibility.

If the court please, this line of testimony is introduced as bearing on the question of the duty of a man employed in the Bureau of Standards with respect to work done in the bureau. The plaintiff's whole case is based upon the theory that some obligation flows out of some duty growing out of the employment of a man in the Bureau of Standards. I am now prepared to inquire of Dr. Dellinger as to a man also employed in like circumstances as these. I want to know something about this so-called duty and this so-called implied contract that arises. It is directly in point, of course, and it is directly in line with the plaintiff's case.

Mr. HOLTZOFF. I submit it is not proper cross-examination.

Mr. HUGHES. Many of the papers that Mr. Holtzoff has introduced and that your honor has admitted under the theory that perhaps it did have something to do with that——

The COURT. We do not know anything about these patents that were issued to Mr. Kolster.

We do not know that in any sense they cover the inventions that were part of his duties.

Mr. HUGHES. I shall bring that out. I am just asking Dr. Dellinger to qualify by examining the patents and the scientific paper issued by the Bureau of Standards, to see whether they cover the same subject. This is merely preliminary. I understand that I have to bring it within the scope of this theory.

Mr. HOLTZOFF. I suggest, if your honor please, that that is not proper cross-examination, because it does not relate to any manner as to which the witness was examined on direct. He is now asking whether or not some other member of the Bureau of Standards took out private patents on some invention which that member made in the Bureau of Standards. Is that it?

Mr. HUGHES. That is precisely it.

Mr. HOLTZOFF. I object to that as not only not proper cross-examination but as absolutely irrelevant, incompetent, and immaterial, and having no bearing upon any issue in this case.

Let us assume that there was some other employee of the Government who failed in his duty to assign his inventions. Let us say it was his duty to assign his inventions to his employer, namely, the United States, such inventions as he might have made in the course of his employment, and suppose the Government for some reason failed to enforce its rights in the premises; has that any bearing upon the question whether the rights that the Government might have in the case before your honor, should or should not be enforced? Does it have any bearing upon the question as to whether or not there is a legal duty on the part of Lowell and Dunmore to assign the inventions in suit to the Government?

I submit, respectfully, that it has no bearing on the matter at all. Your honor might have a certain right against half a dozen individuals, and you may fail to enforce it against five of those individuals. Does that prevent you from enforcing the right against the sixth individual, if the sixth individual pleads as a defense that you have not enforced the rights against the five others? That is practically what counsel for the defense is suggesting.

The COURT. My difficulty is with the position of Kolster, and the position of Lowell and Dunmore may be identical, and I think what was done by the United States has some probative value; and on that score, I think this is cross-examination.

Mr. HOLTZOFF. Well, irrespective of whether it is cross-examination or not, I raise the objection, if your honor please, the additional objection which goes to the merits of the admissibility of such testimony. I say even if they were to call witnesses to testify in chief, that there were certain other individuals in the Bureau of Standards

who took out private patents on occasions as to which the Government failed to enforce its rights, I say that has no bearing upon the question as to whether we have the right to compel Lowell and Dunmore to assign their patents to the Government. For all that appears, we may not have known that this man Kolster took out these patents or some other individual of the Bureau of Standards, because a man can go outside and employ an attorney and apply for a patent, and his employer would not know anything about it. In this particular case, that your honor has before you, the fact that Lowell and Dunmore took out these patents was brought to the attention of the Government, and the Government is seeking to enforce its rights. The fact that in other instances other people who are employed by the Government have taken out patents, and the Government failed to enforce its rights, is immaterial, because the Government may never have had the matter brought to its notice. Your honor may have an employee and that employee may go out and take out a patent, and your honor may never know about it.

The COURT. The objection is overruled. I think this is in cross-examination.

Mr. HOLTZOFF. May I have an exception?

The COURT. Let an exception be noted.

By Mr. HUGHES:

Q. Now, Doctor, have you had an opportunity to examine the claims of the patents and the substance of the publications in the bureau work?

Mr. HOLTZOFF. That calls for expert opinion, if your honor please, as to whether a matter was in a publication and is covered by the claims of the patent. That involves the question of construing the claims of the patent, and I do not know whether——

Mr. HUGHES. It is calling for a question of plain fact, if the court please.

The COURT. I think it is rather an expert opinion.

Mr. HUGHES. But, if so, Mr. Holtzoff has qualified Dr. Dellinger as an expert.

Mr. HOLTZOFF. On science, but not as an expert as construing patent claims, because that is a mixed question of science and law, so to speak.

The COURT. You are calling upon him to construe this patent?

Mr. HUGHES. I am simply asking whether the claims in the patent cover the same subject matter, that is a matter of just reading words, as the article in the bureau covers. That same examination was resorted to in the infringement suit, and I think there is no doubt that any physicist is perfectly competent, and there is nothing

esoteric about it. Furthermore, Dr. Dellinger was in the bureau at the time and it was part of his duty to read these papers, similar papers introduced by Mr. Holtzoff already in three intances.

Mr. HOLTZOFF. I do not question the capacity of the witness to read the publication. It is merely the question of applying the patent claims and comparing them with the publication, which is more or less a matter of expert legal opinion.

Mr. HUGHES. I do not place any technical effect on the word "claims" in the patent, except that that is the phraseology usually used. I want to know whether the patents cover the same matter which is written or spoken of in the bulletin which was issued and gotten out and written by Dr. Kolster.

The COURT. I think the question does call for patent-expert opinion in regard to the scope of these claims, and on that ground I think it is objectionable.

By Mr. HUGHES:

Q. Let me see if Dr. Dellinger can qualify. Dr. Dellinger, have you read the claims in the patents?

A. No.

Q. If after you read them, could you interpret them; do you know what they mean?

A. I am quite unfamiliar with the patent claims and with patents generally. I have not made a study of patents.

Q. Can you read a patent and tell what it is all about?

A. Ordinarily speaking, I would find it difficult and require a large amount of study to speak with any confidence on the contents of a radio patent. It does not come within my experience.

Q. Doctor, can you answer this question: Is the disclosure of the patent covered by the scientific paper?

A. I can hardly understand the difference between that and the previous question.

Q. Can you read the patents and tell what they disclose? Let me ask you this question? Just let me have one of these patents. What is that patent about?

A. I will read you the title: "Radio Method and Apparatus," and as I start to attempt to answer your questions, the very difficulties appear which indicate the difficulty in which I find myself on looking over and attempting to construe patents which I mentioned a moment ago. The first significant sentence is "My invention relates to radio signalling or control systems involving the transmission through the natural media of electro-radiant energy or electro-magnetic waves for telegraphy, telephony or other signalling or control purposes." That contains no specific information of course.

Q. But is that subject covered in the scientific paper?

A. I am inclined to think that every paper ever written on radio is covered by that subject.

Q. I want to know if the scientific paper covers what you have just read from the patent?

The COURT. Mr. Hughes, we are going far afield from patents and inventions involved in this suit.

Mr. HUGHES. No, your honor. Here is a man who was at the bureau at the same time that these circumstances transpired, and I think that this is directly pertinent because it shows the conduct of the bureau. The conduct of the bureau in a host of cases—I propose to bring before this court a number of cases and this is not the only one—the course of conduct speaks louder than anything else as to the attitude and rights of what the Government might do.

The COURT. This part of the matter I will reserve until to-morrow.

The COURT. Just before adjournment yesterday Doctor Dellinger was under cross-examination by Mr. Hughes, and he was being questioned in regard to the procurement of patents by other employees in this section other than Mr. Lowell and Mr. Dunmore. Now, it is my recollection that the subject of procurement of patents by other employees other than Lowell and Dunmore was not the subject of direct examination. I am fortified in that recollection by a reference to the record itself. On page 296 of the stenographer's minutes, the question at the foot of the page:

"By Mr. HOLTZOFF:

"Q. Did you at any time have any conference or conversations with Mr. Lowell or Mr. Dunmore, or both of them, in reference to any patents that might be applied for or obtained or developments made by them at the bureau?

"Mr. HUGHES. We object. The question might be a proper one if it was restricted to the patent in suit, but we are not interested in any other patent.

"Mr. HOLTZOFF. I am willing to accept that amendment. I will limit my question to any patent that might be obtained on the development consisting of either the radio relay or the alternating-current receiving set or loud-speaker."

Accordingly, the direct examination was so confined. I reserved decision overnight, and my decision is that this line of cross-examination is improper.

Of course, this does not prejudice the defendant in its defense. We will meet that exact matter when it arises; but at this stage, I am perfectly clear that this cross-examination is improper.

Mr. HUGHES. May I have an exception, if the court please?

The COURT. Exception is granted.

Mr. HOLTZOFF. Mr. Hughes, may I remind you that there is a question which was left open yesterday. You asked the witness to examine his weekly report cards after court adjourned yesterday, so that he might state whether or not there are any entries in those cards relating to the matters here involved. I believe that the witness has done so. You can have his answer.

Cross-examination (continued):

The WITNESS. I have examined all the weekly report cards that I understood you asked me to, namely, from December 12, 1921, to July 14, 1923.

I find some references on these cards relating to alternating current, first in the relay device, next in the receiving-set device, and thirdly in the loud-speaker device. In the card for February 13th to 18th, 1922, I find one reference under the general heading "Publications" an entry "Lowell's amplifier with A. C. supply."

A card on March 27th to April 1, 1922, under the general heading "Line Radio," I find the entry "Tried line as antenna with Lowell A. C. amplifier."

Q. What is the date of that?

A. March 27th to April 1, 1922, and on the same card under the general heading "Information," "Memo and material of D. Wilhelm, including comparison of beacon and compass A. C. supply amplifier." In this and in the others, if it is agreeable, I will read the full words where I had abbreviations on the card.

On the card of May 1st to 6th under the heading of "Visitors" I have the entry "General Squier and Vice President Staber, of All American Cables, May 5th, re A. C. supply amplifier and translation of PURC into Spanish." PURC being the name of a book.

Then I find two entries which I believe refer to the A. C. relay which is in question here, although there is a possibility that they refer to the D. C. relay, but it is my belief, I think, that they refer to the A. C. relay and therefore I suppose that I should include those, and one is on a card dated April 22nd to 27th to 29, 1922, and is the entry with the general heading "Lecture on Radio Developments Before Royal Canadian Society, April 22nd." That does not mention the relay devices, but that is an entry pertaining to it, because I took the relay with me to use in demonstration in connection with that lecture.

The other similar case is an entry on the card of June 12th to 17th, 1922, under the general heading "Visitors," "Major J. O. Mauborgne, Signal Corps, re Chicago Radio Congress and use of F. W. D.

relay." That is a similar case where I am not sure that it refers to the A. C. device, but it is my belief that it is the A. C. rather than the D. C.

Then I find on nine subsequent cards references to these devices under the general heading on my cards of "Patent," all of the references in these following cases being to activities in connection with patent protection on these devices.

July 10th to 15th, 1922, under the heading "Patents," "cf.," which I believe meant conferred—"SWS, JLP, P. D. L. patent on A. C. amplifier, also plans on patent for capacity altimeter."

Mr. HOLTZOFF. May we ask the witness to state what those initials stand for?

The WITNESS. The first S. W. S. are the initials of S. W. Stratton, director of the bureau; J. L. P. are the initials of J. L. Preston, a member of the radio section, and P. D. L. are the initials of P. D. Lowell. On the card July 17th to 22nd, 1922, under the heading "Patents," "Arrangements re Government rights in patent on amplifier with A. C. supply."

On the card, July 24 to 29, 1922, under the heading of "Patents," there is "c. f.," meaning, I believe, conferred.

"R. S. O. et al. Redrafted Westinghouse letter re regenerative-set description. Conferred H. D. H. re letters re A. C. supply amplifier and capacity altimeter."

The first, R. S. O., refers to R. S. Ould, a member of the radio section.

H. D. H. are the initials of H. D. Hubbard, who was chief of the office division of the bureau, and I think he had the title at that time of secretary of the bureau.

On the card for September 18th to 23rd, 1922, under the heading "Patents"—"conferred Knight and H. D. H. re A. C. amplifier. Conferred H. D. H. and Richardson re capacity altimeter."

H. D. H. is the same H. D. Hubbard previously mentioned.

Q. Doctor, I think that is pretty well over the period in controversy, and I shall not require any further statement on that.

Mr. HOLTZOFF. Just a moment, I think the witness should finish his answer.

The COURT. I think the witness should complete the answer to the question.

Mr. HUGHES. I think he has completed the answer, if the court please. He is now over into a time very much subsequent to any facts involved in the controversy.

Mr. HOLTZOFF. He is within the period over which you asked him to examine these cards.

Mr. HUGHES. I am quite willing to have him go ahead.

Mr. HOLTZOFF. I think he should.

Q. Very well, Doctor, proceed.

A. On the card September 25th to 30th, 1922, under the heading "Patents," "Conferred Knight," and over that word I find the figure 9–25, meaning September 25th. "A. C. amplifier and capacity altimeter patents."

Under card October 2nd to 7th, 1922, under the heading "Patents," "conferred F. W. D. patent on radio relay."

On the card December 4 to 9th, 1922, under the head of "Patents," "critic," which means "criticized bill of complaint," etc.

That refers to a bill of complaint against Lowell and Dunmore drawn up by the Department of Justice on the A. C. amplifier patent.

Q. Was that bill filed?

A. I do not know.

Q. Have you ever heard anything about the bill since?

A. I am not certain whether I have heard of it since this date or not.

Q. Do you know what ever became of it? Did anything ever come of it?

A. I recall that the procedure involved in this bill of complaint was begun by the Department of Justice at the request of the Department of Commerce, and that subsequently the Department of Commerce and the Department of Justice agreed to drop the proceeding. But whether it was before or after the filing of the bill of complaint, that is a legal detail on which I am not informed.

Q. In other words, you do recall that the Department of Justice and the Department of Commerce agreed to drop the proceeding?

A. Yes.

On the card December 11 to 16, 1922, under the heading "Patents," "Conferred Mothershead A. C. amplifier capacity altimeter."

On the card December 25 to 30, 1922, under the heading "Patents," "Revised papers on A. C. supply amplifier."

I recognize the document you handed me entitled "Annual Report of the Director of the Bureau of Standards to the Secretary of Commerce for the Fiscal Year Ended July 30, 1921," as the official publication of the Bureau of Standards for that period.

Mr. HUGHES. I ask that this document be marked for identification, if the court please.

(Received and marked "Defendant's Exhibit E for identification.")

I recognize this document entitled "Annual Report of the Director of the Bureau of Standards to the Secretary of Commerce for the Fiscal Year Ending June 30, 1922," as the official annual publication of the bureau.

Mr. HUGHES. I ask that this document be marked for identification.

(Received and marked "Defendant's Exhibit F for identification.")

I have never read this report in toto. For that reason I cannot say whether the report correctly states and relates the activities of the Bureau of Standards for the year 1921. It is the official annual report of the director and as such is a report of the work of the bureau for the year.

Upon your request I have read the paragraph on page 17 of the report, under the heading "Definition of Standards."

The fiscal year in the bureau is from July 1st of one year to June 30th of the following year. From July 1, 1921, to June 30, 1922, would be the fiscal year for that period.

Examining the passages in the 1921–1922 report under the heading "Definition of Standards," these records, so far as I know, portray the operation of the bureau with respect to standards.

In the radio section, for the fiscal year 1921–1922, my section was engaged in the testing, or standardization and calibration of various radio devices. This included standardizing decremeters; that is, a measuring or standardizing operation.

A decremeter is a machine, or device, for measuring a falling of radio waves. It shows the extent of decline. That is substantially right.

The radio section has tested condensers from time to time almost continuously, and I believe that those were included at that time. We also did some work on wave meters, which are measuring devices. The work on condensers was also measuring and standardizing condensers.

About that time, in addition to work of measuring or standardizing condensers, there was some research or development work on the improvement of condensers, but whether it was within this period I am not certain. Along that general line, although I cannot be entirely certain that it is within that period, we did some work on the standardization of ammeters.

My section also did some work on inductors, radio tubes, heterodyne generators, and measured and standardized insulating material. The work on inductors included measuring and standardizing and also theoretical work on design of inductors and calculation of their constants.

We also did some work about this time on measuring the high-frequency resistance of inductance coils and some work on measuring of the field radiated from two horizontal coils. As I said in most of my testimony, I can not be sure that they came within this period, but in all of these cases they were within or near this period.

We did some work on standardizing radio-wave meters, measuring the effective capacity of multilayer coils with square and circular sections, and the measurement and calculation of inductance of circular coils. I am not certain whether this latter work was done in the radio section at that time, but I am inclined to think that it was.

Q. Did your section or not put a vast amount of time or a substantial amount of time on the interference qualities of continuous waves?

A. I recall that we did put some time on it. As I recall, the work being entirely theoretical or calculation work. I do not at the moment recall doing any laboratory or experimental work.

As to whether the substantial work of the bureau from July 1, 1921, to April 1, 1922, was in measuring and standardizing these radio devices, I should say that that was only one line of the work that could be described as substantial during that period. It would be difficult to say that that was the main line of work, because the work for the Air Service was also a substantial line, and I do not recall the proportion of the section's efforts or expenditures that went into them.

Other than the work I have mentioned my section also did some work that could be described as research work, which was neither for the Air Service nor would be desirable as measurement and standardization work. This research work was done for the general public. It would be very difficult to say what proportion of time was put in on this type of work, without making a careful study of the projects and the records of the men's time, all of which is vague in my mind.

Yes; I have testified that in 1920 I discussed certain problems with Lieutenant Van Zandt, an officer of the Air Service, on proposed laboratory work. At that time Mr. Kolster was head of the development part of the section. The discussions were with Mr. Kolster, as well as with Mr. Whittemore and myself.

Mr. HOLTZOFF. If your honor please, at this time, the Government wishes to file and offer as a part of its evidence the deposition of Mr. Buckley, taken at Washington, D. C., on October 3, 1930. We desire to read that deposition in evidence.

(Deposition of John P. Buckley read in evidence, which is as follows:)

JOHN P. BUCKLEY, having been duly sworn, was examined and testified as follows:

My full name is John P. Buckley and my place of residence is 3611 Idaho Avenue, Washington, D. C. My occupation is mechanical draftsman for the Bureau of Standards. I am registered as a mechanical draftsman, but I am employed mostly for illustrating circulars.

I have been employed in the bureau for about 13 years. My duties are to make drawings of anything that might come to my

department; it may be one thing or another; circuit diagrams or designs in making boxes or cabinets and such work. Let it be understood I am not a designer of radio circuits. In other words, I mean that I make drawings for members of the bureau staff in connection with their work.

I am attached to the radio section, but I also work outside of the radio building very often.

I know Percival D. Lowell and Francis W. Dunmore. They are employes of the Bureau of Standards; that is, Mr. Dunmore is an employe of the bureau and Mr. Lowell was an employe some years ago. Since that time he has resigned and has taken a position outside of the bureau.

I had occasion to come in contact with Mr. Lowell and Mr. Dunmore quite frequently. The nature of those contacts was in the general work of the section, such as designing cases for radio sets or to make finished drawings from their rough drafts.

I made drawings at the direction of Mr. Lowell and Mr. Dunmore quite frequently. These drawings related to radio circuits and cases for containing the various elements of radio sets. At that time, namely, in 1920, 1921, 1922, and perhaps 1923, I kept a record of the work that I did at the bureau, but from that time I do not believe I have been making any work reports. During 1921 and 1922 I made quite a number of drawings for Mr. Lowell and for Mr. Dunmore.

This group of cards I have represents my work reports for the various members of the section. Each of these cards contains an entry for each day showing what I did on the particular day.

There is one card for an entire week and these cards are a part of the Bureau of Standards records. After I made these cards out I turned them in to the chief of the radio section. I turned them in once a week. At the end of each week I turned in the card for the week past. There is a date stated on each card showing the work done during that week.

Mr. HOLTZOFF. I offer in evidence the group of cards identified by Mr. Buckley.

(Received in evidence and marked "Plaintiff's Exhibit No. 52.")

The WITNESS. I can not, by consulting these cards, refresh my recollection as to the dates on which I made drawings for Mr. Lowell or Mr. Dunmore, or both, or what the nature of the drawings were, other than as the cards show. For instance, it says:

July 4, 1921. Designing and drafting. Made four drawings for Mr. Dreit, two drawings for Mr. Zahn, three for Mr. Dunmore. Supervised work left with machinist and carpenters. In charge of files.

The week commencing July 4, 1921, and ending July 9, 1921, made three drawings for Mr. Dunmore.

For the week commencing July 18, 1921, ending July 23rd, made two drawings for Mr. Dunmore, four drawings for Mr. Dunmore, altered drawings for Mr. Dunmore.

For the week from July 25 to July 30, 1921, made five drawings for Mr. Dunmore.

For the week commencing August 29, ending September 3rd, made two drawings for Mr. Dunmore.

For the week, September 12, 1921, to September 17, 1921, made one drawing for Mr. Dunmore.

For the week, September 26, 1921, ending October 1, 1921, made one drawing for Mr. Dunmore.

For the week, October 3rd, ending October 8th, made two drawings for Mr. Dunmore.

For the week, October the 17th, ending October 22nd, made two drawings for Mr. Dunmore.

For the week, October 24th, ending October 29th, two drawings for Mr. Dunmore.

For the week, October 31st, ending November the 5th, made two drawings for Mr. Dunmore.

For the week of November 7th, ending November 12th, made one drawing for Mr. Lowell.

For the week November 21, ending November 26, made four drawings for Mr. Dunmore.

For the week January 2nd, ending January 7th, made three drawings for Mr. Dunmore.

For the week January 23rd—I find some of the cards are missing here.

For the week November 21, ending November 26, made four drawings for Mr. Dunmore.

For the week November the 28th, ending December the 3rd, there is nothing there for either Lowell or Dunmore.

I was on leave December 5th to December 31st, 1921.

January 2 to January 7, 1922, made three drawings for Mr. Dunmore.

For the week January 9 to 14 there is no work performed for Mr. Dunmore or Mr. Lowell.

For the week January 16 to 21 no work performed for Mr. Lowell or Mr. Dunmore.

For the week January 23 to January 28 made one drawing for Mr. Dunmore.

For the week January 30 to February 4 made one drawing for Mr. Dunmore, made six drawings for Mr. Lowell.

For the week February the 6th to 11th no work performed for Mr. Dunmore or Mr. Lowell.

For the week February 13 to February 18 made one drawing for Mr. Dunmore and six drawings for Mr. Lowell.

For the week February 20 to February 25 made five drawings for Mr. Lowell.

For the week February 27 to March the 4th no work performed for Mr. Lowell or Mr. Dunmore.

For the week March the 6th to March the 11th made one drawing for Mr. Dunmore.

For the week March the 13th to March the 18th no work appearing for Mr. Lowell or Mr. Dunmore.

For the week March the 20th to March the 25th no work appearing for Mr. Lowell or Mr. Dunmore.

For the week March the 27th to April the 1st no work appearing for Mr. Lowell or Mr. Dunmore.

For the week April the 3rd to April the 8th no work appearing for Mr. Lowell or Mr. Dunmore.

For the week April the 10th to April the 15th made two drawings for Mr. Dunmore.

For the week April the 17th to April the 22nd no work appearing for Mr. Lowell or Mr. Dunmore.

For the week April the 24th to April 29th no work appearing for Mr. Lowell or Mr. Dunmore.

For the week May the 1st to May the 6th, made one drawing for Mr. Dunmore.

For the week May the 8th to May the 13th, no work appearing for Mr. Lowell or Mr. Dunmore.

For the week May the 15th to May the 20th, no work appearing for Mr. Dunmore or Mr. Lowell.

For the week May the 22nd to May 27th, one drawing made for Mr. Dunmore.

For the week May the 29th to June the 3rd, no work appearing for Mr. Dunmore or Mr. Lowell.

For the week June the 5th to June the 10th, no work appearing for Mr. Dunmore or Mr. Lowell.

For the week June the 12th to June the 17th, made two drawings for Mr. Dunmore.

For the week June the 19th to June the 24th, made two drawings for Mr. Dunmore.

For the week June the 26th to July the 1st, made one drawing for Mr. Dunmore.

For the week July the 3rd to July the 8th, no work appearing for Mr. Dunmore or Mr. Lowell.

For the week July 10 to July 15, made one drawing for Mr. Dunmore.

For the week July the 17th to July the 22nd, made one drawing for Mr. Dunmore.

During 1921 and 1922, as I remember, there were a great number of projects being worked upon. One in particular Mr. Dunmore worked on in 1921 was a relay. Some of the drawings which I made, as I have just testified, had to do with this radio relay, remote relay. Bureau of Standards drawings 784–A, 784–B, and 784–C that I have here were drawn by me. The initials "J. P. B." after the word "drawn" and the word "traced" are my initials, and I put them on the drawings myself.

The date appearing on drawing 784–A is October 31, 1921; as to number 784–B, Nov. 1, 1921; and 784–C, Nov. 1, 1921. I put those dates on these drawings at the time of finishing them and the dates are in my handwriting.

These drawings were made in my office in the radio section of the Bureau of Standards during office hours under the direction of Mr. Dunmore and Mr. Lowell. The initials on these drawings appearing after the words "Checked and approved" on all three drawings are "F. W. D.," meaning F. W. Dunmore. I know the handwriting; it is Mr. Dunmore's.

I remember distinctly having made drawing 891 that I have here. The initials "J. P. B." after the words "Drawn" and "Traced" are in my own handwriting. This drawing was made on December 31, 1921, under the direction of Mr. Lowell and Mr. Dunmore, and was made in my office at the bureau during office hours. The initials appearing after the word "Checked" are Mr. Dunmore's and Mr. Lowell's. These initials are not in their handwriting because they are printed letters. After the word "approved" are the initials "J. H. D."—J. H. Dellinger, who is chief of the radio section.

Mr. HOLTZOFF. I offer in evidence the drawings identified by the witness, the same being drawings 784–A, 784–B, and 784–C, and 891.

(Drawing 784–A received in evidence and marked "Plaintiff's Exhibit No. 53.")

(Drawing No. 784–B received in evidence and marked "Plaintiff's Exhibit No. 54.")

(Drawing No. 784–C received in evidence and marked "Plaintiff's Exhibit No. 55.")

(Drawing No. 891 received in evidence and marked "Plaintiff's Exhibit No. 56.")

I have here Scientific Paper of the Bureau of Standards, No. 450, entitled "An Electron Tube Amplifier Using 60-Cycle Alternating Current to Supply Power for the Filaments and Plates" and I made the drawings shown in Figures 1, 2, 3, 4, and 5. I made these drawings under the direction of Mr. Lowell in my office at the Bureau of Standards during office hours.

Mr. HOLTZOFF. I offer this photograph in evidence.

(Received in evidence and marked "Plaintiff's Exhibit No. 57.")

This photograph I have represents the remote control relay as designed by Mr. Dunmore. The only thing I had to do with the layout of the parts of that remote control was to follow the instructions of Mr. Dunmore. All I did on the relay was to make the finished drawings from Mr. Dunmore's rough sketches. For instance, I placed the various instruments in a much better form and appearance than in Mr. Dunmore's rough draft.

I did not lay out the various parts or elements of the relay proper, but I did lay out the panel as it appears in the picture. Where a case was to be ordered it was customary for them to pile the things together and then for me to take the dimensions and order the case. In panel work, while I followed instructions, here and there I would change slightly the appearance of it, in order to balance the effect, to make it look more like a finished design. The work that I did on the details of the design of the panel was such as this. You might have these two binding posts over here (on the left) and I would move them slightly in order to balance these two on the right; you might have this switch up too near this knob and I would move it down; thus giving it more of a balanced appearance. I did this work in the Bureau of Standards in my office during office hours at the request of Mr. Lowell and Mr. Dunmore.

Mr. HOLTZOFF. I offer this paper in evidence.

(Received in evidence and marked "Plaintiff's Exhibit No. 58.")

WITNESS. This photograph I have here I recognize as a picture of the amplifier unit and also the rectifier unit. As I recall, the entire apparatus is the amplifier and to the right of it is the rectifying unit, in which the power supply was furnished to the amplifier.

As I recall, I had this to do with the layout of the parts. I recall the panel of the amplifying unit—Mr. Lowell approached me and wanted me to make a drawing of the panel. I suggested to him that he furnish a bakelite panel, and I would give him the points, evenly divided and properly spaced for him to drill. Very often he would go down in the shop and make his own work. In this connection he made this panel, as I recall it. I did not make any suggestions to him as to how the various parts should be fastened or arranged.

He had them piled up for me to take the measurements as to the size of the case. I recall the placement of two batteries, two dry cells of the searchlight type, and I suggested to him placing them as they are shown in the picture. This gave him more room in placing them in this manner.

Mr. HOLTZOFF. I offer this photograph in evidence.

(Received in evidence and marked "Plaintiff's Exhibit No. 59.")

The WITNESS. As I remember, I did the work for Mr. Dunmore on the relay shown on plaintiff's Exhibit No. 58, and the work for Mr. Lowell and Mr. Dunmore on the apparatus shown on plaintiff's Exhibit No. 59 some time in the latter part of 1921 and the early part of 1922. Other than the drawings that have been offered in evidence in connection with these two pieces of apparatus I might have made pencil drawings for Mr. Lowell to go down in the shop and work out. None of these were retained as they were merely memorandum drawings and were thrown away after he had finished the work. It was the custom to make drawings for the various members of the radio division as requested by them.

Cross-examination:

I have referred to certain sketches given me by Messrs. Lowell and Dunmore. None of them have been placed in evidence here—I do not see any of the sketches. These sketches were presented to me sometimes on a sheet of paper and sometimes from their work books. These two books you have handed me I identify as Mr. Dunmore's work book and Mr. Lowell's work book. I recognize the handwriting in them as their handwriting.

(The books above referred to have already been introduced in evidence as "Plaintiff's Exhibits Nos. 26 and 27.")

The WITNESS. Referring to plaintiff's Exhibit No. 26, there is a drawing on page 51 of which I made a copy. I made this drawing for him, which is found on page 41 of this book. It must be understood that in copying from the sheet of paper, or from the books, it was often the case that I would take a portion of one drawing and a portion of another drawing in order to complete what they really wanted as a finished drawing.

The particular sketch appearing on page 41 of plaintiff's Exhibit 26 was made by Mr. Dunmore. It appears that drawing No. 891 (plaintiff's Exhibit 56) is the one that I sketched him from page 41.

The sketch that I refer to on page 51 of plaintiff's Exhibit 26 was made by Mr. Dunmore. Page 51 also identifies drawing No. 891. As I mentioned before, it was the habit of Mr. Dunmore and Mr. Lowell in directing the drawing to take from one or two sketches—such as changing the value of a condenser, or something of that sort.

Referring to the sketch on page 41, which was made by Mr. Dunmore, and comparing it to drawing No. 784–A, it is the same except for the fact that page 41 shows a single contacting switch, whereas the drawing shows two such contacting switches. As I recall it, the one contacting switch of page 41 was made into two parts, one of finer adjustment than the other.

The sketch I had before me when I made drawing 784–A is the sketch appearing on page 41 of plaintiff's Exhibit No. 26.

The sketch on page 49 of plaintiff's Exhibit No. 26 was made by Mr. Dunmore. I am not able to recall when I first saw that sketch, but it was some time in the latter part of December, 1921.

In my direct examination I referred to my office. In the northwest corner of the room I had my table and desk. Midway in the room, or slightly north of the center line of the room, were worktables—about three or four in all. The workbench supporting tools and anvils and the like appears at the south end of the room. Adjacent thereto is a table supporting a coil-winding machine. I occupied the drafting table. Mr. Lowell and Mr. Dunmore mostly worked on the worktables. The layout of the circuits of the sets were for the most of the time on these worktables.

I was in attendance at my duties during this time each day up to December 5th and from that time I was on leave until December 31st. Very often, while I was on leave, I would return for an hour or two a day to finish up some work for the section.

My time card is correct, that I was on leave from December 5th until December 31, 1921, but, as I mentioned, it was my habit to return while on leave to do some special work. This time would be taken off later to compensate for my extra work.

Drawing No. 891, which was checked by F. W. Dunmore and P. D. Lowell, and dated December 31, 1921, is one of the drawings that I made during my visit to the section while on leave. It occurs to me that I returned for the visit to the section because I visited the section during the holidays, Christmas time, and afterwards. As I mentioned, when extra work was performed, it was given to me later at my choice of time.

Q. Well, now, on your visit to the section can you tell us what Lowell and Dunmore were doing at that time?

A. They were working very diligently on their amplifier and the relay in it.

Q. Can you tell us more clearly as to just what you mean by "their amplifier"?

A. As appearing on page 51 of Dunmore's book [indicating Exhibit 9] and page 41 of the same book.

Q. Just what were they doing on the amplifier?

A. Why, they were perfecting the amplifier in December. At that time it was on tables one and two [indicating on pencil sketch], in bread-board fashion, but working perfectly. My attention was called several times to how POZ came in.

Q. What else did you receive beside POZ, if anything?

A. From broadcasting music and speech. Where the music or speech was loud enough the tones were quite pure there. A slight, a very slight, hum when at rest and not receiving a message.

Q. What kind of power did Lowell and Dunmore use to energize the circuits of the amplifier?

A. They used a battery and A. C. in starting, and finally got it to work entirely by A. C., supplying the filament and the circuit as a whole.

Q. Can you point out on the diagram on page 49 of the notebook just how the power was supplied?

A. It must be understood that I am not a radio engineer; but it is very evident from this sketch that the 110-volt A. C. supplied the various elements of the circuit, as appearing in the left-hand end of the circuit. The transformer was evidently tapped for these various elements.

Q. Now, you have referred to the operation of an amplifier during some visit you made to the laboratory in 1921. Just what power was used in operating that amplifier?

A. 110-volt A. C.

Q. Where was the 110-volt A. C. obtained from?

A. From the room. We have it connected up around the room to be tapped at the various tables.

Q. Well, now, would you say that the hum of the alternating current which you observed tended to mask or distort the signal?

A. No. The hum was very slight, and became very much overpowered by broadcasting or code.

Q. Now, who was present when you saw the operation of this amplifier?

A. Mr. Dunmore and Mr. Lowell and Mr. Ould and other employees of the section coming in and out of the room.

Q. Can you tell us who some of those other employees were?

A. Why, as mentioned, I recall Mr. Ould, and Mr. Kruse, I think. Outside of employees, Colonel Marlboro—Marlboro, isn't it?

Mr. Holtzoff. Mauborgne.

A. (Continued.) Colonel Mauborgne and Mr. Duncan.

Referring to the radio laboratory—there were two rooms to the west of the one I have already mentioned. I am not familiar with their numbers, but I am under the impression that Mr. Dunmore and Mr. Ould occupied one of them while the other was a small room occupied by Dr. Dellinger. I am under the impression that Dr. Dellinger's assistant also occupied this latter room for a time. I am under the impression that Mr. Dunmore was Dr. Dellinger's assistant at that time, Dr. Dellinger being the chief of the radio section.

Q. You have said that during your visit to the radio laboratory in December, 1921, you heard a certain alternating-current operated radio receiver actually operate. Now, what kind of signals were being received and reproduced?

A. Code and broadcasting.

Q. Now, what do you mean by broadcasting?

A. Receiving music.

Q. And where was that music being transmitted from?

A. I do not recall the stations. I think there were a number of stations. The code came from POZ.

Q. In addition to the music, was there any other type of broadcasting?

A. Code was received.

Q. Was there anything accompanying the music?

A. No. The tones were quite pure and satisfactory; that is, when the broadcasting was of sufficient strength to be heard.

Q. Intermediate to the broadcasting, did you ever hear any announcing or speech being received?

A. Yes. The usual announcements were made as of that time.

Q. Well, what effect did the alternating-current supply have upon the quality of reception of such speech or announcing?

A. It was quite free from the A. C. hum.

At this time Dr. Dellinger had an assistant—a Mr. Whittemore, as it comes to me now—long since resigned from the section. I might add that he also occupied that room, as it appears to me now. He has been out of the section for so long that I have forgotten.

Mr. BRADY. It is stipulated and agreed by counsel that at the time over which Mr. Buckley's testimony extends, Mr. L. E. Whittemore was alternate chief of the radio section of the Bureau of Standards, with Dr. J. H. Dellinger.

The WITNESS. I have stated that I made up the originals of certain figures appearing in the paper marked "Plaintiff's Exhibit No. 57." Mr. Lowell furnished the sketches from which I made the original drawings for this paper.

In Mr. Lowell's work book, or laboratory notebook, plaintiff's Exhibit No. 27, from which I obtained data for the preparation of the drawings shown in plaintiff's Exhibit No. 57, I find in a number of these sketches the power unit is very much in evidence; but in making a finished circuit diagram for publication, these circuits have to be smoothed out; and at the first glance they do not resemble the one that is smoothed out for publication, but the elements appear; that is, the power unit and the various condensers and the crystal detector and, finally, the complete application of the alternating current to the amplifier, no batteries having been used finally.

Referring to page 49 of the notebook (Plaintiff's Exhibit No. 27) the smooth drawing, Figure 1 on page 346, compares with the drawing on page 49 in this way: It is noted that in writing this circular that they gradually worked up to a climax, as appearing on page 350 of the same circular, the five drawings showing the various steps of

such approach. The rough sketches in the book identify the principle of applying the 110-volt alternating current.

Referring again to where Mr. Whittemore was located, I remember now that he was in the same room with Dr. Dellinger. Mr. Whittemore very seldom came in the radio laboratory, the room in which I was located, and the room in which Mr. Lowell and Mr. Dunmore were doing their work. I seldom saw Dr. Dellinger in the room, he being quite busy in his own office most of the time.

I have referred to certain diagrams, particularly plaintiff's Exhibits 53, 54, and 57. As my contribution to those diagrams, I only made the drawings, as copied from the rough draft of Mr. Lowell and Mr. Dunmore.

I have been in the Government service for over thirty years. My first appointment was in the War Department; I have been at the Bureau of Standards for about thirteen years. I am employed there at this time.

Redirect examination:

Q. Mr. Buckley, did you hear the amplifier operated on the alternating current to which you have testified in room 203 of the Bureau of Standards on more than one occasion or only on one occasion?

A. On more than one occasion.

Q. On about how many occasions would you say?

A. Well, about ten or fifteen times.

Q. And over what period of time?

A. During December, 1921.

Q. Well, did you ever hear it after December, 1921?

A. Yes.

Q. During what period of time did you hear it?

A. In January.

Q. And not after that?

A. I do not recall the extension of that time, because it became an everyday fact and I had no more interest—the amplifier had become an everyday fact, and I had no more interest in it.

Referring once more to page 41 and page 51 of Mr. Dunmore's laboratory notebook (plaintiff's Exhibit 26), page 41, as shown, represents the relay with elements appearing as furnishing alternating current power instead of battery power. On page 51 there are elements identifying the relay and also the amplifier. For instance, the power unit is shown there as supplying the various tubes, as A current and B current. On page 49 it would appear that the alternating current supplies the set, no battery power appearing. In other words, it is an amplifier or receiving set.

Referring to Mr. Lowell's note book (Plaintiff's Exhibit No. 27) on pages 22 and 24, the circuits show the rectification of the current as by the crystal and in the first instance with the battery application.

These circuits were shown to me, together with a copy of them, of smoother design, to copy from. When I say "these circuits" I mean that the note book and the smoother copy of the diagrams were shown to me.

(The sketch prepared by the witness during his examination was received in evidence and marked "Plaintiff's Exhibit No. 60.")

Defendant's motion to dismiss

Mr. HUGHES. If your honor please, I move to dismiss, and my grounds are these: First, that no authority has been shown, no authority of law either constitutional or legislative in any one in the Bureau of Standards to acquire title to the patents claimed. Secondly, that no authority, constitutional or legislative, has been shown in any one representing the United States Government to acquire title to these patents. And thirdly, that no contract between the Bureau of Standards and Messrs. Lowell and Dunmore has been shown for the assignment of the patents to the Government.

It is, as we conceive it, necessary that these points be affirmatively established by the Government in the making out of a prima facie case and it is for the failure to establish these points that this motion is called to the attention of the court.

The COURT. Mr. Hughes, assuming that your motion in an equity suit is proper, it appears to involve the entire merits of this controversy, and the motion to dismiss the bills is denied.

Mr. HUGHES. I think probably, if my motion is proper, it would be proper for me to take an exception. I should like to take an exception for the record, if your honor please.

The COURT. Let an exception be entered.

Defendant's evidence

FRANCIS W. DUNMORE, being duly sworn, was examined and testified as follows:

I live at 3411 Rodman Street, Washington, D. C., I am 39 years of age, and I am a physicist at the Bureau of Standards, having been associated with the bureau since January, 1918.

These documents are my certificates of appointment which I received, the first one being received when I entered the Bureau of Standards and the others when I was either promoted or there was a change of appropriation. The signature appearing on these sheets is my signature.

Mr. BRADY. I ask that the document be marked in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 1.")

I did not execute anything else with regard to my employment with the Government. I did not have any agreement with the Government other than these appointments. No one told me when I came to the bureau that any inventions I might make would become the exclusive property of the Government. I was never told that I would have to assign to the Government any inventions that I might make.

No one ever gave me any reason why the Government would be interested in an exclusive license to inventions that I might make.

As far as I know, the United States Government does not manufacture, nor has it ever manufactured, alternating-current operated radio sets for receiving radio broadcast programs in the home.

When I came to the bureau in 1918 I reported to Frederick A. Kolster. At that time Mr. Kolster was chief of the radio laboratory. Other members of the radio laboratory of the Bureau of Standards at that time were Percival D. Lowell, Laurens E. Whittemore, J. H. Dellinger, and Mr. Willoughby. These men that I have named were subordinates to Mr. Kolster.

My duties were in connection with calibrating and adjusting the Kolster decremeters and in making measurements on inductance coils and calculations on the inductance of a single-turn loop, and high-frequency resistance measurements of coils, and I also did some measurement work on the effect of shielding of copper screening.

Mr. BRADY:

Q. Did Mr. Kolster ever tell you anything about patents for inventions? He was your bureau chief.

A. Yes, sir.

The COURT. Now, what is your objection?

Mr. HOLTZOFF. I object to this question on the ground that a statement made by the immediate superior to this witness does not bind the Government.

Mr. BRADY. Your honor, this man was the subordinate of F. A. Kolster and we are inquiring as to what Mr. Kolster told the witness and it seems to me entirely proper.

The COURT. How is it relevant in this case as determining the legal rights of the United States?

Mr. BRADY. We are endeavoring to find how this entire matter of patents arose and the first thing that we know is that the witness received certain information from F. A. Kolster, his chief, and we want to know what it was.

The COURT. Suppose he were told by Mr. Kolster that he could patent anything he wanted. Would that be pertinent in this case?

Mr. HUGHES. It would be pertinent in this way, if the court please:

The plaintiff has rested its case on what it calls a duty growing out of the employment. Here is a construction of that duty by the chief of this very man. It is therefore probative as having some bearing on what that duty was. That is the pertinency of it.

Mr. HOLTZOFF. The scope of the duty is a question of law; that is, the work that a man was to do may be construed by this man's chief, but the legal incidents growing out of that work and the legal effects constitute a question of law for your honor to determine.

Suppose Mr. Kolster misinterpreted or misconstrued the law and misinformed this witness as to his legal rights, assuming for the sake of argument that he had done that; that would have no bearing upon the issues in this case.

Mr. HUGHES. That would be a question for the cross-examination for the plaintiff to rebut in its own way. Here is testimony offered bearing on the question of duty that the Government has rested its case on. It is probative on what that duty was, touching upon what the duty was.

The COURT. The question is as to what he was told by Mr. Kolster in regard to the issuance of the patents?

Mr. HOLTZOFF. That is the question.

The COURT. I can not see that that has any relevancy to the case. I therefore sustain the objection.

Mr. HUGHES. May we have an exception?

The COURT. Certainly.

(See Dunmore testimony taken under Rule 46 on page 208.)

The WITNESS. Prior to March 27, 1922, no one ever told me that I must assign patents for my inventions to the Government.

Mr. Kolster left the bureau in February, 1921. I was under the supervision of Mr. Kolster from January, 1918, to February, 1921, or for a period of three years.

While Mr. Kolster was at the Bureau of Standards he made several inventions. Some of them pertained to direction finding.

Q. Do you know whether or not F. A. Kolster patented those inventions?

A. Yes; he did.

Mr. HOLTZOFF. I move to strike that out as having no bearing upon any issue in this case. Whether somebody else took out patents has no bearing upon the question of whether the patents here in suit belong to the Government.

The COURT. What happened in matters of other inventions I think we are not dealing with in this case, because all the circumstances attendant on these inventions are the very essence of the

controversy. These other patents in regard to other inventions, I think are not pertinent. I sustain the objection.

Mr. HUGHES. May we have an exception to that, if the court please?

The COURT. Certainly. Let an exception be entered.

The WITNESS. There has been offered in evidence by the plaintiff as Exhibit No. 18 a list of radio projects for United States Air Service for outline of work, and I observe project No. 42 is entitled "Airship Bomb Control and Marine Torpedo Control." Under that heading I observe three items:

"1. Devise secret signalling system to use with Air Service selector.

"2. Inspect Hammond receiving set.

"3. Seek relay to operate from 10 to 12 times per second on 500 microamperes."

In looking at this list I can say that I worked on the last item. I was not directed to work on it, but I picked it out among a number of different problems that were before us on aircraft radio as one of particular interest and having perhaps a rather easy solution and worked on it. I did not receive any instructions with respect to this project.

The purpose of the airship bomb control and marine torpedo control relay on this list was this: On aircraft without a pilot it is necessary to release bombs by some radio method of signal sent from the ground. The purpose of this relay was to have a device intermediate between the radio receiving set on the airplane and the trigger device which dropped the bomb. This relay was put in between the receiving set and the trigger to cause the radio signal to work the trigger.

The relay was to be operated from the same source of power that the radio receiving set operated from, which, of course, was the batteries on the airplane. They were storage batteries to supply the filament and the customary dry-cell B batteries to operate the plate and small C batteries for the grid if necessary.

When I started my work I was familiar with another kind of relay, the one which had been worked on by Dr. Eckhardt in the sound section of the bureau.

I have here a publication entitled "Journal of the Washington Academy of Sciences," dated July 19, 1921, containing an article by E. A. Eckhardt and J. C. Karcher, page 303. I am familiar with the contents of that article. It shows a relay device for use with a radio receiving set and consists of a vacuum tube with a mechanical relay in the plate circuit of the tube and a coil in the plate circuit and a coil in the grid circuit, these two coils being coupled together

to produce radio oscillations in the tube. This coupling was adjusted as well as the grid bias until the tube was just about to oscillate and in this state it was ready to receive the radio signal which in turn set it into oscillation, causing an increase in plate current, which caused the relay device in the plate circuit to operate. This relay worked entirely from batteries.

Mr. BRADY. I ask that the article be marked in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 2.")

The relay which I set up and which is shown on page 40, under September 23, 1921, of my notebook (plaintiff's Exhibit No. 26) consisted of substantially the same apparatus as Mr. Eckhardt used, except that the two coils in the grid and plate circuit were taken out and the tube used in a nonregenerative state and another tube put in parallel with it to make it a little more sensitive. That relay would have served the purposes of the Air Service.

After I set up the relay which I have just described as of September 23, 1921, in my notebook (plaintiff's Exhibit No. 26) I proceeded to take it off the breadboard on which it was mounted and put it in a box so that it would be more compact and suitable for the use of the Air Service. This was done, and the fact that it was ready for the Air Service was reported to my superior, Dr. Dellinger. I believe it stayed there in the laboratory for some seven or eight months.

After that the relay was sent to Dayton, Ohio, for the purpose for which it was constructed, namely, to release bombs from aircraft by means of a radio signal from the ground.

There is no problem of eliminating the hum of alternating current in an aircraft relay because the sound of the engine and motor of the plane would be heard way above any little hum and furthermore the relay is not connected with the human ear and so there is no hum to be heard, and certainly there is, of course, no source of hum on the aircraft for producing a hum in a relay.

The aircraft relay did not involve any problem of a loud speaker such as shown in Letters Patent No. 1606212 (plaintiff's Exhibit No. 3). The relay did not involve any function of a loud speaker because the relay is a device to operate a mechanism and a loud speaker is for the human ear.

The aircraft relay did not involve any problem of grid bias from rectified alternating current, such as is shown in my patent No. 1635117 (plaintiff's Exhibit No. 1), for the reason, as I have said before, principally because there was no source of hum on aircraft. By a source of hum I mean that the receiving equipment on aircraft is operated from batteries which supply a smooth source of current to the receiving set in contradiction to the hum produced by house lighting circuit on the ground. The frequency of the usual house lighting circuit on the ground is 60 cycles.

Mr. Lowell and I completed the invention shown in patent No. 1455141 (plaintiff's Exhibit No. 2) on December 10, 1921. There are two records showing the completion of this invention on December 10, 1921; one contained in my notebook (plaintiff's Exhibit No. 26) shown under that date on page 49; the other is on my weekly report card (plaintiff's Exhibit No. 24) for that date. Referring to my weekly report card under date of December 10, it shows the following entry:

"Made up list of proposed work. Set up a detector and two stages of audio with filaments on A. C. Used stabilizer with center caps going to grids. Also used C batteries. Got rid of hum."

I do not recall having said that I completed the invention. Mr. Lowell and I worked jointly on it. I made the records with respect to the invention.

Q. Well, now, will you refer to the claims of Letters Patent No. 1455141, and state whether or not they are supported by the completion of your invention in December, 1921?

Mr. HOLTZOFF. I object to that, if your honor please, as calling for a legal opinion of the witness.

The COURT. Objection overruled.

Mr. HOLTZOFF. I respectfully except.

The COURT. Let an exception be entered.

A. Yes. Take, for example, claim 1, and referring to the circuit on page 49 under date of December 10. The claim reads:

"In an apparatus for receiving radio signals—"

Of course, this circuit diagram shows an apparatus for receiving radio signals.

"A combination of a source of signal energy."

This is shown by the terminals G and F, indicating the antenna and ground over which the signal energy comes in.

"Means for amplifying said signal energy."

This means is shown by the three first tubes beginning from left to right.

"Means for rectifying said signal energy."

This is indicated by the fourth tube.

"A source of alternating current for supplying power to said amplifying means."

This is shown by the transformer at the left marked 110 volts A. C., which supplies the filament power to operate the filaments and the plate power through the rectifier as shown at the lower part of the figure.

"A plurality of means in circuit with said amplifying means for eliminating the hum of said alternating current in said apparatus."

A plurality of means are indicated by the resistors or stabilizers as shown by the little wiggly lines with the arrows on them, also by the 30 m. f. condenser and the two coils marked ⅞ and the resistance marked 32 ohms.

I can continue with all the claims, reading them similarly on that diagram, if you so desire.

This paper I have is a certified copy of a nonexclusive license which Mr. Lowell and I offered the Government under patent No. 1455141. This paper bears my signature.

Mr. BRADY. I ask that the license be offered in evidence.

Mr. HOLTZOFF. I object to the introduction of this paper as incompetent and as having no bearing on any of the issues in this case. They tendered us a nonexclusive license under one of these patents. We are asking for title and not a mere license under all of the three patents. What relevancy is it that they tendered us a license? What does it tend to prove? It has no bearing upon the issues in this case.

The COURT. The pertinency of it is not apparent to my mind, but I think it should be admitted.

(Received in evidence and marked "Defendant's Exhibit No. 3.")

The WITNESS. This license was never returned by the Government to me or to my attorneys. It is dated May 2, 1925. Since that time, I think it has been in the files of the department, either the Department of Justice or the Department of Commerce, I can not say definitely.

The license was delivered to the Department of Commerce shortly after May, 1925; probably within the next day or two.

Q. Were you ever assigned to work on the alternating current operated radio receiving set?

A. No.

Q. Did Dr. Dellinger ever instruct you how to make the alternating current operated radio receiving set?

A. No.

Q. Did anyone in the radio laboratory instruct you how to make the radio receiving set to operate from alternating current?

A. No.

Q. Did Mr. Whittemore direct you or instruct you as to how to make the alternating current operated radio receiving set?

A. No.

Q. What instructions were given you with respect to the making of an alternating current operated radio receiving set?

A. I received no instructions whatsoever.

Q. Did you ever have any conversation with Dr. Dellinger on the design of an alternating current operated radio receiving set in the year 1921?

A. No.

Q. Did Dr. Dellinger or anybody in authority ask you to devise a way to operate a radio receiving set on alternating current?

A. No.

Mr. Lowell's and my patent No. 1455141 was in interference in the Patent Office with four parties, namely, the Wired Radio, Inc., the Latour Corporation, Pupin, and Blatterman. The Government was informed of these interference proceedings.

Mr. HOLTZOFF. I am perfectly willing to stipulate at the request of the defendant's counsel that the Government had notice of the pendency of this interference proceeding. We took no part in the defense. Three of the four parties were Government employees. I do not know that that fact is pertinent to any issues in the case, but I am perfectly willing to state that to be the fact.

A very large amount of testimony was taken in those proceedings. I attended all of the sessions of the taking of testimony. To my recollection, the Government did not have a representative at any of those sessions. Testimony was also taken by our opponents in this proceeding.

There has been a decision in this interference proceeding. The examiner rendered a decision to the effect that Mr. Lowell and I were the first inventors of the patent in question. That decision was rendered perhaps a year and a half ago, or a year ago.

This patent has been in interference since its issue and still is. All of our opponents have appealed from the decision and the case is now pending on appeal and has not yet been heard.

I have a photograph here which is a picture of the first receiving set for operation on house-lighting current which Mr. Lowell made, with some suggestions from me, while at the Radio Instrument Company in Washington, after he left the Bureau of Standards. This apparatus was operated from the house-lighting circuit of 60 cycles, 110 volts.

The function of the apparatus was to reproduce radiobroadcast reception without the use of batteries, and it functioned in that manner. I think that apparatus is now in the office of my attorney, Mr. Brady.

Mr. BRADY. The photograph referred to by the witness is offered in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 4.")

The WITNESS. I have another photograph here and it discloses an apparatus embodying our invention, which I made up with Mr. Lowell's help, and contains the full disclosures of our invention and

it works entirely from the house-lighting circuit, and it is self-contained in a box with a loud speaker. It uses the so-called peanut or N tubes.

This apparatus contained a tube detector. It also included a power transformer for which we drew up specifications and had to have made specially by the American Transformer Company since it was the first one of its type ever made.

Mr. BRADY. The photograph is offered in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 5.")

The WITNESS. I have a third photograph and it also discloses the embodiment of our invention in receiving apparatus, in this case a neutrodyne type of receiving set. It also contains the power supply unit in a separate box, and contains a special transformer which was purchased from the American Transformer Company. This set was made about a year after the previous one which I have just been discussing. This set also had a tube detector. The receiving sets shown in the two photographs were used at various times to interest various parties and several demonstrations were made of their operation at various places, operating entirely from a house-lighting circuit.

Mr. BRADY. The third photograph is offered in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 6.")

Referring to plaintiff's Exhibit No. 1, Letters Patent No. 1635117, dated July 5, 1927, covering a signal-receiving system, the particular feature involved in this patent is the obtaining of the negative bias which is customary to put on tubes of broadcast receiving sets from the alternating-current supply of the house-lighting current. The tubes were not biased from the alternating current. The current was rectified and smoothed out properly so that the biasing voltage was direct current.

The grid circuit disclosed in patent No. 1635117 was energized from power from the alternating-current supply or residence lighting current, but of course this power was not put directly on these grids; it was put through proper rectifying tubes and smoothing-out devices, so that the voltage put on the grids was smooth and free from hum. It is customary in operating radio tubes in radio broadcast receiving sets to put what we call a negative voltage on the grids of the tubes so that they may function properly, and it was the purpose of this invention to obtain that negative voltage primarily to operate at the 110-volt 60-cycle house-lighting circuit. I defined bias by saying that the tubes needed a negative voltage, and this negative voltage I construe as a bias.

I conceived the subject matter of patent No. 1635117 on December 3, 1921, and my weekly report card for that date shows this disclosure. The entry on my card for that date is:

"Spent morning and part of the afternoon putting permanent set-ups in room 203 in working order. Worked out circuit to get both grid and plate voltage 60-cycle A. C."

That means from the 60-cycle alternating-current line.

This invention was completed by me on December 16, 1921, as is clearly set forth in my notebook (Plaintiff's Exhibit No. 26) under that date on page 51, that diagram embodying all the claims described in the patent. I made the entry under date of December 16, 1921. It is shown on the opposite page from this circuit and there is a description and signatures of two witnesses.

I will point out briefly how the claims of patent No. 1635117 read upon the diagram of December 16, 1921. Taking claim 9, it says:

"A signal-receiving system comprising in combination an audio-frequency amplifier, including an electron tube having grid filament and plate electrode."

These tubes are shown in the top center of the diagram with the grid filament and plate electrodes.

"An input circuit interlinking said grid and filament electrodes."

This input circuit is shown by the long line on the left-hand side of the diagram with the coil in it and the condenser marked .0006 mf as well as the audio transformer shown by the two coils with the straight lines in between them.

"An output circuit interlinking said plate and filament electrodes."

The output circuit is the plate circuit of the tubes in the top center of the diagram. This output circuit contains the reproducing means.

"A source of alternating current."

That is clearly shown by the little rectangle at the bottom of the page with the coils on it, this being a transformer, the primary of which is connected to the 60-cycle house-lighting current, and the secondary coils to the various elements of the circuit.

"Means for rectifying said current."

These means are shown by the two tubes in the lower part of the circuit, the plates and grids of these tubes being connected together so that they form rectifiers.

"Means for supplying a negative potential to the grid electrode of said electron tubes from said source of alternating current."

The tube shown in the lower left-hand side of the diagram is the means for supplying the grid electrode of said electron tube, this tube taking the alternating current and rectifying it and supplying it as a direct current to bias the grids in the tubes shown at the top of the diagram.

"And means for supplying a positive potential to said plate electrodes from said source of alternating current whereby said audio-frequency amplifier operates to amplify signalling energy without interference from said source of alternating current."

The means for supplying the positive plate potential is the tube shown in the lower right-hand corner of the diagram, this being a rectifier tube, and being so connected that a positive direct current potential is put on the plates of the two tubes shown in the top of the diagram.

This combination produces an amplifier which operates without interference from the source of alternating current.

The apparatus shown in the diagram under date of December 16, 1921, page 51, of my notebook (Plaintiff's Exhibit No. 26) would not function on aircraft as there would be no way of supplying power to the various tubes in this apparatus because it is designed purely for operation from the house-lighting current, and there is no such source of supply available on an airplane.

I never received any instructions from Dr. Dellinger or Mr. Whittemore to eliminate batteries on the grid circuit of an electron tube system. I never received any instructions from any one in the radio laboratory to eliminate batteries from the grid circuit of an electron tube system.

No officer of the Government has ever made any demand upon me in writing for an assignment of the title of Letters Patent No. 1475141, which was issued May 15, 1923, prior to the filing of the several bills of complaint in the present proceedings in April, 1930.

No officer of the Government has ever made any demand in any manner whatsoever for an assignment of title to my patent No. 1635117 (plaintiff's Exhibit No. 1), for a signal receiving system, issued on July 5, 1927, prior to the filing of the bills of complaint in the present proceeding.

My patent No. 1635117 has no relation whatsoever to aircraft radio. It was a device to operate with house-lighting current.

The particular feature of patent No. 1606212, issued on November 9, 1926, to Percival D. Lowell and myself, is that it covers a method of energizing a dynamic type of loud speaker from the alternating-current house-lighting circuit. The purpose of this apparatus was to enable one to obtain good loud speaker reproduction with the dynamic type of loud speaker without the use of batteries, the speaker being energized from the house-lighting circuit. Broadcast reception was to be received with the apparatus of this patent.

Mr. Lowell and I conceived the subject matter of this patent on January 20, 1922, as is shown by my notebook (Plaintiff's Exhibit No. 26) under that date on page 57, which shows a complete disclosure of the invention involved.

Mr. Lowell and I completed the invention of the electro-dynamic speaker on January 25, 1922. The completion of the invention is recorded in Mr. Lowell's notebook (plaintiff's Exhibit No. 27) under

that date on a leaflet inserted opposite page 48. I note under date of January 26th Mr. Lowell makes this statement:

"The complete circuit disclosed on page 49"—page 49 is blank except for the leaflet pasted in and he further states: "The complete circuit disclosed on page 49 works very nicely, there being a negligible amount of hum present which is not objectionable. Radiophone speech and music was picked up from several places and reproduced with as much clearness as when batteries are used throughout."

I was not assigned to work on an alternating current operated power speaker, such as is shown in patent No. 1606212.

Mr. BRADY. It is stipulated by and between counsel that the subject matter of patent No. 1606212 is supported by the disclosures referred to by Mr. Dunmore—that is, the disclosures found in plaintiff's Exhibit No. 27 under dates January 20, 1922, and January 26, 1922.

The WITNESS. No officer of the Government has ever demanded from me in any manner an assignment of title to patent No. 1606212, issued November 9 1926, prior to the filing of the several bills of complaint in these proceedings in April, 1930.

At the time of making the invention on the loud-speaker—that is, the invention of patent No. 1606212—no one told me that the Government wanted or desired an exclusive right under this power-operated speaker patent.

I wrote the article appearing in plaintiff's Exhibit No. 48, in the Journal of the American Institute of Electrical Engineers for April, 1922, entitled "A Relay Recorder for Remote Control by Radio."

Plaintiff's Exhibit No. 32 is a report dated November 15 to December 15, 1921, written by myself. On page 2 of that report I referred to certain experiments. Those experiments had nothing whatsoever to do with aircraft radio.

Neither Dr. Dellinger nor anyone in authority asked me to devise a way to operate a radio receiving set on alternating current, or to devise a grid bias circuit for an electron tube system operating from alternating current, or a power amplifier or loud-speaker operated from alternating current.

Q. In the interference proceedings which you have referred to concerning your patent No. 1455141, do you know what kind of a right the United States Government has in the applications of the interfering parties?

Mr. HOLTZOFF. I object to that as immaterial, irrelevant and incompetent, and having no bearing upon the issues in this case.

Mr. BRADY. Your honor, the interference has been going on for over five years and have been fought by Lowell and Dunmore with an invitation to the Government to assist, and we want to know why that condition has existed.

Mr. HOLTZOFF. What condition?

Mr. BRADY. Why it is that the Government claims this property at this time and yet has permitted these men to build the property up without any assistance whatsoever from the Federal Government,

Mr. HOLTZOFF. What bearing has that upon our legal rights?

Mr. BRADY. Your honor, if these men had not contested and opposed this very heavy and lengthy interference proceeding, the patent would have been devoured years ago and there would not have been any patent.

Mr. HOLTZOFF. That has no bearing upon the question as to whom the patent legally belongs. We say it belongs to the Government.

Mr. HUGHES. If the court please, it shows an attitude of the Government towards this so-called duty that the Government rests its case on.

Mr. HOLTZOFF. Suppose that the Government, as is sometimes the case with big institutions, moved very slowly to recover its property. Has that any bearing upon its rights to recovery?

The COURT. The suggestion is that through this interference the rights of these patentees would have been lost long ago, and yet you claim title to something that you might have lost because of inactivity.

Mr. HOLTZOFF. If Lowell and Dunmore had been defeated in the interference proceeding, possibly one of the patents here might have been invalid, but that has no bearing upon the question as to whether the patent belongs to Lowell and Dunmore or whether it belongs to the United States Government.

The COURT. I agree it has no binding force, but for what it is worth I think I will let it go in.

Mr. HOLTZOFF. But the question that Mr. Brady asks is not the question that he was discussing.

The COURT. Let us have the question repeated.

(Last question repeated as recorded.)

Mr. HOLTZOFF. I claim that calls for a conclusion of law and it may well be that the Government is in equity and in good conscience entitled to all these applications. We have not brought suit against the other applicants because they were not successful in the interference proceeding.

Mr. HUGHES. He has asked, if he knows, and if he does not know that is the answer.

Mr. HOLTZOFF. It is a mixed question of law and fact as to what our rights are to the other application.

The COURT. I have very great doubts as to the propriety of the question, but I may be in error. The objection is overruled and the question will be answered.

Mr. HOLTZOFF. May I have an exception?

The COURT. Let an exception be entered.

A. Yes, I believe the Government has a nonexclusive license under these patents or applications.

By Mr. BRADY:

Q. 129. Do you know Albert S. Blatterman?

A. Yes.

Q. 130. Where was he employed when you knew him?

A. At Little Silver, New Jersey, in the laboratory there, the Signal Corps laboratory.

Q. 131. What service was he employed in?

Mr. HOLTZOFF. I am perfectly willing to stipulate, if you wish, Mr. Brady, that at the time Mr. Blatterman claims he made the invention he was a Government employee and made the invention, I believe, in a Government laboratory.

The COURT. Are we dealing with some other invention not in this suit?

Mr. BRADY. The invention is the same invention, your honor, claimed by a great many different people.

The COURT. This is one of the interference men?

Mr. BRADY. Yes, your honor. We have certified copies of correspondence here showing that all of the parties have given the Government a license under these applications. That license is of a nonexclusive character.

The COURT. I can not see the pertinency of that, Mr. Brady. What has that got to do with the issue in this case?

Mr. HUGHES. It has this, and nothing else, if the court please:

It shows the attitude of the Government, which now comes in and claims title over a course of time toward these identical inventions. These patentees are brought into interference in the Patent Office, which, of course, means this:

I claim a patent, Mr. Mahaffy claims a patent, and they are set up one against the other, and there is a hearing, and we find out which is the one who really has the thing.

That was done in this case, not by one other claimant but by three admitted claimants, very much in the situation of these men.

The Government has nonexclusive licenses from the others. That is less than title. It claims it has title to these, and yet notwithstand-

ing the fact that it was invited to come into this suit and defend if it thought it had any interest, it elected to stay out. That is a course of conduct—

The COURT. That is in evidence, is it not?

Mr. HOLTZOFF. That is in evidence, that we took no part in the interference proceeding. I conceded that.

Mr. HUGHES. The distinction between the others and these men is that the Government had nonexclusive licenses under them, which is less than title, and yet that being the case, a certain course of action followed. The question is simply a follow-up question from the stipulation which was entered into. It should have been asked then. I simply want to repair what I conceive should have been done then.

Mr. HOLTZOFF. We do not know that the circumstances under which the other three parties to the interference proceeding made their invention entitled the Government to the invention itself, or only entitled it to a nonexclusive license, because there might be circumstances under which the Government is only entitled to a nonexclusive license.

If the question is relevant, we would have to try the other three cases here, which I do not suppose your honor wants to do, because they are not involved.

The COURT. I think that point is well taken. The situation of these interferences certainly was not similar to the situation of the employees of the Government here.

Mr. HUGHES. It was, in the sense that their applications were brought out while the applicants were Government employees.

The COURT. Yes; but we do not want to try the rights of these other people.

Mr. HUGHES. No; this is no interference action. All I want to do is to supplement the stipulation entered into already about these interference records, purely for the purpose of showing a course of action on the part of the Government with respect to these patents.

The COURT. Let us have the question read.

(Q. 129, 130, and 131 repeated as recorded.)

The COURT. I can not see the pertinency of that last question as bearing on the issues in this case. I sustain the objection.

By Mr. HUGHES:

Q. Mr. Dunmore, do you know as a matter of fact whether or not Blatterman had given the Government a nonexclusive license?

Mr. HOLTZOFF. I object to that on the same ground.

The COURT. It seems to me that is entirely outside the issues in this case.

Mr. HUGHES. It has the pertinency that I have already attempted to point out to the court, and nothing more. I shall withdraw the question.

By Mr. BRADY:

Q. Mr. Dunmore, did the Government intervene in the interference proceedings which have extended since the issuance of the patent?

Mr. HOLTZOFF. We have already stipulated that we have not.

Q. Mr. Whittemore has testified that he made an entry on a time-card reading:

"Conference F. W. D. and Major Young, re patent on relay."

I have an entry on my card for December 5, 1921 (plaintiff's Exhibit No. 24), which is as follows:

"December 5, 1921, tried audio tuning on two stages of audio amplifier and found it worked O. K. Went down to Air Service patent section regarding patent on receiving relay."

The WITNESS. I have a letter here dated December 13, 1921, and I received the original of that letter. It was written by Lieut. Harmon in the patent section of the Air Service.

By Mr. BRADY:

Q. What occasion did Lieutenant Harmon have to write that letter to you?

A. I had been down to the patent section with the permission of either Mr. Whittemore or Dr. Dellinger to discuss the question of taking out a patent on a relay and this letter states that I should proceed with an application for a patent.

Mr. HOLTZOFF. I move to strike out the witness's statement as to what the letter says. The letter does not say, as a matter of fact, that the witness should proceed with the application for the patent. The letter stands for itself.

The COURT. That objection seems to be justified. The letter speaks for itself.

Mr. BRADY. The letter identified by the witness is offered in evidence.

What is the attachment to the letter from Lieutenant Harmon?

A. It is a description of the type A relay which I believe I took with me when I went down.

Mr. BRADY. The letter to the witness from Lieutenant Harmon and the attachments thereon are offered in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 7.")

The WITNESS. The type A relay was the one which I have already testified to as being described in my note book (Plaintiff's Exhibit No. 26) under date of September 23, 1921. I had in mind the type A relay described in my notebook on September 23 and October 7, 1921.

I have a copy of a letter here the original of which was sent by myself to Lieutenant Harmon.

Mr. BRADY. The letter is offered in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 8.")

The publication of the report contained in that letter was the article which is already in evidence in the proceedings of the American Institute of Electrical Engineers regarding the relay recorder for remote control by radio. In the upper left hand figure on page 312 the type A relay is shown in that article.

I did not at any time make any admission to any officer of the Government or of the Bureau of Standards that the Government was entitled to demand that the patents covering inventions as to which I have testified should be dedicated to the public.

Cross-examination:

Q. In 1920, 1921, and 1922 your work at the bureau was principally research and development work, was it not?

Mr. HUGHES. I think that is not a proper question. It certainly is designed to call for a conclusion. I think the question ought to be directed to what the man did do, and not ask him for conclusions as to what his work may have been.

The COURT. Objection overruled.

Mr. HUGHES. Exception, please.

The COURT. Let an exception be entered.

A. It was about half and half. I did a lot of calibrating work. I calibrated direction finders on lighthouse tenders. I did some radiotelephone work, putting a radiotelephone on a lifeboat at Atlantic City. I made some telephone tests with the Post Office Department.

I stated a little while ago that I testified in the interference proceeding which involved one of the patents here in suit. I remember testifying to this effect:

"Q. Were you among those whose time cards Dr. Dellinger followed closely?

"A. I think perhaps I was.

"Q. What was the work of an important nature which produced this close following of the time cards?

"A. By important nature I mean in contradistinction to most of the work of the laboratory, which was of a routine nature, to that of the more interesting type of work of a development nature."

Yes; I remember testifying to that effect.

I would not infer from that statement that a considerable part of my time was devoted to work of a development nature. Some time was devoted. I said before, about half of my time. I would not say that is considerable; I would say more than half would be considerable.

Work of a development nature does not in any sense mean work of an inventive nature. By development nature work I mean that

of the type of this Coast Guard work. No; not the Coast Guard but the life-boat work, the telephone work wherein I developed the radio telephone and adapted it to the life boat. That was development work, but involved no invention.

It is a fact that development work might involve invention. Invention might be an incident that arose in the course of development work; invention might arise in the course of any work.

I do not recall specifically whether I was also engaged in research work during this same period of time. Research and development are closely related. Research and development, I would say, can be construed as about the same.

Q. And when you are working on a particular problem in research or development, is it not a fact that other problems suggest themselves as you go along which arise in the course of the development?

A. I do not think you can work on any problem in any nature of work without getting some thoughts.

Q. Do you remember testifying in the interference proceedings: "I often got off on little side problems, since anyone engaged in research work will tell you when working on one problem others are presented. When such others were presented and occurred to me and Lowell too, and Mr. Kolster, we would switch off occasionally and tackle these problems sufficiently to see if they were worth going into in greater detail." Do you remember that testimony?

A. Yes.

Q. Was that testimony correct?

A. Yes.

Q. And do you remember testifying in the same proceeding "While it might interfere somewhat with the assigned problem, the results in many cases more than justified it since it was these little side problems that oftentimes developed into the big main problem later on"?

A. Yes.

Q. And was that testimony correct?

A. Yes.

Q. Do I understand by that testimony that as you were working on some problems that might be assigned to you other problems might suggest themselves as offshoots that you would explore the possibilities of?

A. They might be entirely unrelated in some instances, because my mind was not always fixed definitely on a particular problem. An inventive type of mind jumps suddenly sometimes to entirely new things.

Q. When you were assigned to a particular task, did you consider that you were at liberty to jump to anything that might occur to you?

A. I have been so trained under Mr. Kolster; yes.

Q. And you felt that when you did that you were performing one of the duties of your employment, did you not?

Mr. HUGHES. This is immaterial; but it is certainly not in cross-examination, and I object to that on that ground.

The COURT. Just how is this in cross-examination?

Mr. HOLTZOFF. I consider it relevant on cross-examination, because there seems to be a distinction drawn by Mr. Dunmore in his direct testimony as to the two types of relay; one, apparently, he seemed to argue in his direct examination, was part of his official duties that he was working on in connection with Air Service projects and the other was something else, and I am cross-examining him on that issue.

The COURT. I think that is proper.

Mr. HUGHES. Exception, please.

The COURT. Objection is overruled and let an exception be entered.

(Last question repeated as recorded.)

A. My duties were not specifically outlined enough to answer that question.

Mr. HOLTZOFF. I think the question is capable of an answer, and I suggest that the reporter read the question again.

Mr. HUGHES. It is an impossible question to answer. The witness has answered the question.

Mr. HOLTZOFF. I submit that he has not.

The COURT. Repeat the question.

(Last question repeated as recorded.)

A. My answer still stands.

By Mr. HOLTZOFF:

Q. Did you or did you not feel that you were performing one of the duties of your employment when you got off on a side problem?

A. My duties were never outlined to me——

Q. I am asking you what you felt, Mr. Dunmore. Did you feel that you were performing the duties of your employment?

The COURT. Is that question objected to?

Mr. HUGHES. Yes.

The COURT. Objection sustained.

Mr. HOLTZOFF. I respectfully except.

The COURT. Let an exception be entered.

The WITNESS. I frequently got off on side problems while I was working at the bureau.

Q. Did you devote any substantial portion of your time on side problems when you were carrying on an assigned task of research or development?

Mr. HUGHES. I think that last question is distinctly objectionable, when you were carrying on an assigned task of research development.

The COURT. The objection is overruled.

(Exception noted for defendant by direction of the court.)

The WITNESS. Not substantial; no.

It is difficult to estimate how great a proportion of my time was taken up with side problems, but I would say a few hours out of each week, maybe four or five hours.

Q. Suppose, when you investigated a side problem in a preliminary fashion, it occurred to you as a desirable main problem, to use your own wording, to work on later. Would you then suggest it to your superior as a main problem to be taken up?

A. Probably, when the first opportunity arose, but usually that type of problem is such that it is probably pretty well worked out in a few hours before any report is made.

Q. You testified in the interference proceeding that sometimes it was these little side problems that oftentimes developed into the big main problems later on. How did these side problems develop into the big main problem later on?

A. I gave an example of that in my testimony.

Q. Give it now.

A. Mr. Lowell was working on a cross-coil direction finder, and he probably spent half an hour on a couple of coils and made a test which is the basic invention involved in the present-day radio beacon, guiding mail planes.

Q. And the development of that radio beacon became an assigned problem later on, did it not?

A. The perfection of it, not the conception and reduction to practice.

Q. But the development of the radio beacon afterwards became a main assigned problem, did it not? I am not now arguing with you when the patentable conception took place. But is it not a fact that after this idea occurred to Mr. Lowell he was put to work upon this problem?

A. No; I don't recall definitely that he was put to work on that particular problem.

Q. Well, now, when you explore side problems of this nature do you make notations of them in your weekly report cards?

A. Sometimes, and sometimes not.

Q. Well, how do you distinguish when to do it and when not to do it?

A. Well, because I had two sets of records, and sometimes some things were in one record and not in another, and at other times they were in one and not in the other.

Q. What were the two sets of records?

A. I kept these weekly time cards, and I had a notebook.

Q. Well, would every side problem that you would investigate be recorded in one of those two records?

A. No.

Q. Would some of them be recorded in one record and some in the other?

A. They may not be recorded in either.

Q. How would you determine whether to record such a side investigation?

A. I do not know as I had any particular way of determining it. I just did it or did not do it.

Q. Did it depend upon what appeared to you to be the importance of the problem?

A. Well, the recording came before the importance was often realized.

Q. So it was more or less a matter of accident whether you would record some work that you might do on a side problem?

A. Not an accident; no.

Q. Well then, what determined you in deciding whether or not you would make a record of such a side investigation?

A. It is just whether I happened to or not. There are many important things that I wish now I had made a record of, and some unimportan ones. In the spring of 1921 through to the winter of 1922, there were several men who worked under my instructions and under he instruction of Dr. Dellinger. I was chief of the group of men that worked on project 42.

Q. And in fact you prepared, for the director's signature, reports to the Air Service as to the progress of the work, did you not?

A. I made some suggestions to Mr. Whittemore, and it seems to me he prepared the report. I don't remember now.

Q. Well, now, let us see. I show you a certified carbon copy of a letter dated July 26, 1921, addressed to the chief of the equipment section, navigation branch, Air Service, War Department, signed "Respectfully, Director."

I notice the initials "F. W. D." in the upper left hand corner of that letter. I ask you if those are your initials [handing document to witness]?

A. Yes; but I don't remember the letter. They are my initials.

Q. You mean to say that you don't remember either dictating or preparing the draft of this letter?

A. No.

Q. Well now, suppose you look through the next three letters of this group which apparently bear your initials, and see if you did not prepare these reports for the director's signature, to the Air Service of the War Department [handing document to witness]?

A. I don't understand these letters, because my recollection is that all such reports were prepared or sent out under the signature of either Dr. Dellinger or Mr. Whittemore.

Q. I did not ask you whether they went out under your signature. I am asking whether the initials at the head of these letters are your initials?

A. These are my initials.

Q. And did you prepare them for the signature of the director or Dr. Dellinger?

A. I prepared reports of the work in the Air Service work.

Q. Are these your reports?

A. I did not know they were in the form of letters.

Q. But you did prepare reports for the signature of the Director of the Bureau of Standards or for Dr. Dellinger's signatur, to the Air Service?

A. No, I don't remember preparing them for the purpos of being transmitted anywhere, merely for the information of Dr. Dellinger or the director, but I may have done so.

Q. You may have done so?

A. Yes, I may have.

Q. You don't deny——

A. I don't remember.

Q. You don't deny that these are not carbon copies o the letters that you prepared?

Mr. Hughes. I object, if the court please. The witnes answered that he does not remember. That is all he can answer.

The Court. He said, "I may have done so, bu I do not remember."

Mr. Holtzoff. I offer these certified copies in evidere.

Mr. Hughes. Mr. Holtzoff, will you show us wha about these letters are pertinent?

Mr. Holtzoff. There is nothing in the letters thmselves. The purpose of putting those letters in is to show that Mr. Dunmore was in charge of this Air Service program.

Mr. Hughes. Then I object. It does not showany such thing as that.

Mr. Holtzoff. These are the carbon copies of th memos.

The Court. They might have a slight probatie value, but for what they are worth I will accept them.

Mr. Hughes. May I have an exception?

The Court. Let an exception be entered.

(Received in evidence and marked "Plaintiff' Exhibit No. 61.")

The Witness. In my direct testimony I mae a distinction between the type A and the type B relay. The tpe A relay was the relay recorder for operation on batteries. Aft our work on elimi-

nation of batteries for broadcast reception was started, I had available a power supply unit which connected on to the type A relay, eliminating the use of batteries with the type A, and later when I put the type A relay and the power unit in the same box, I gave it the name of a type B relay, but it was nothing more than a type A relay with a power pack in the box to operate the type A relay without batteries.

The Signal Corps requested a couple of the type B relays and I was told to make them for the Signal Corps.

Q. Do you remember testifying in the interference proceeding: "I think the type B relay was later assigned to me as a problem"?

A. Yes; I so testified.

Q. Was that testimony correct?

A. Yes; but by that I meant assigned to me as a problem in the sense of a problem of constructing one and not conceiving and inventing one.

Q. Of course, the type B relay was an adaptation of the type A relay for the purpose of having it operated from a different source of power, was it not? You so testified, did you not, a few minutes ago?

A. I stated that the type B relay consisted of the type A relay with the power supply unit included in it like the present-day broadcast receiver.

This paper I have with my initials "F. W. D." in my handwriting is an order on the shop for the construction of a panel to be used for receiving relays. It reads:

"Drilling one panel and assembling apparatus on panel for radio receiving relay type B on project 42."

Q. So that type B relay was also a part of project 42, was it not?

A. It may have been put in project 42 some time in 1922. This should have been dated 1922 according to the notes.

Q. What month?

A. January.

Q. Is not that the time you were working on the type B relay, January, 1922?

A. I was merely putting them in a box. I had finished the completion of any——

Q. But the working out of the details of the type B relay came after the 1st of January?

A. No.

Q. The construction of the relay itself. I am not talking about the conception of the idea.

A. Putting the apparatus in a box; yes.

Q. And that was part of project 42?

A. I do not recall that it was, but according to that project 42 is mentioned there.

Q. And you initialed this card?

A. I initialed the card; yes.

Mr. HOLTZOFF. I offer this card in evidence.

The COURT. Admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 62.")

By Mr. HOLTZOFF:

Q. I show you a card entitled "Job requisition, Job No. 10,842," and I ask you if you have seen that card before?

A. I do not recall having seen it.

Q. What does this card represent?

A. It represents a job requisition on the shop to cut, drill, and engrave one bakelite panel for radio recorder.

Q. Does it bear your initials?

A. Not in my handwriting.

Q. No; but does it bear your typewritten initials?

A. Yes.

Q. Don't you remember that on or about the date of this card you requested certain work done in the shop in connection with the relay?

A. No.

Q. You are sure about that?

A. I believe I was working on the relay about that time, but I don't remember that particular card.

Q. I did not ask you whether you remembered that particular card, but do you remember having some work done in the Bureau of Standards shops in connection with the relay?

A. If this date is correct, it is October 26, 1921. As I recall it, that was the period in the work before I got to having shopwork done on it. The panel which this seems to refer to, I would believe would be the one under date of—I do not recall whether it was in the stage of shopwork at that time or not, but I was working on the relay then.

Mr. HOLTZOFF. I ask that this card be marked for identificaton.

(The same was marked "Plaintiff's Exhibit B for identification.")

The WITNESS. My card for April 8, 1921 (which was marked in evidence as "Plaintiff's Exhibit No. 24"), has this entry:

"Talked with Captain Vaughan regarding the aerial-navigaton program."

Captain Vaughan was an Army officer stationed at Dayton, Ohio. He must have been in the aviation branch because Dayton was the headquarters of the Army Air Service. I have no recollection

where we had this talk. The subject under discussion was "Regarding the aerial-navigation program." I can not state more definitely as to what was the discussion.

Q. Let me see if I can refresh your recollection. Did not you discuss the proposed Air Service research program for the coming year?

A. I do not remember that discussion. It was relative to aerial-navigation work; further, I have no recollection.

Q. Well, do you remember whether it was relative to research work in radio that the Bureau of Standards was to do for the Air Corps?

A. It had to do with radio work which the Bureau of Standards was to do. I would not put it necessarily research work.

Q. Radio—it concerned radio work?

A. Yes.

Q. That the Bureau of Standards was to do for the Air Corps?

A. Apparently.

Q. And did you have under discussion the various projects that might be undertaken by the Bureau of Standards for the Air Corps along that line?

A. I do not remember that discussion at all.

Q. Do you remember any other conferences with Captain Vaughan in reference to this matter?

A. No.

Q. Did you have more than one conference with Captain Vaughan?

A. I do not remember that one except from your bringing that to my knowledge.

Q. Well, you were working on the Air Service program, you and your group, is not that so?

A. At some time; whether at this particular time I do not remember definitely.

Q. Well, of course, you would not have had any discussion over this matter with Captain Vaughan unless you had some responsibility in regard to it, would you have?

A. Why, yes; I might have discussed it with him whether I was working on it or not.

Q. This was just a casual conversation, was it?

A. No.

Q. It was of sufficient importance to have a diary record made of it?

A. Yes.

Q. Therefore, it was a conversation in the course of your duties at the bureau, was it not?

Mr. HUGHES. I object. It calls for a pure conclusion of law.

The COURT. This is cross-examination and I think it is proper.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

A. My duties were always very vague and I could not say whether that would come under them or not.

Referring to my laboratory notebook, which has been marked in evidence as Plaintiff's Exhibit No. 26, I notice that opposite to page 54 there is a memorandum pasted in which was written by Mr. Brooks, who was in charge of the instrument section in the electrical section of the Bureau of Standards.

This memorandum represents information such as any person might obtain outside the bureau—such as a civilian coming to the bureau——

Q. Just answer my question. What does this memorandum represent?

A. I am answering you.

Q. No; you are not.

The COURT. The witness is trying to answer your question.

Mr. HOLTZOFF. He is characterizing it.

A. (Continued.) Which I obtained from Mr. Brooks.

Q. And what is the subject matter to which this information relates?

A. It relates to the design of a transformer.

When I obtained this information from Mr. Brooks I apparently had asked for it. How I asked for it I do not recall. He wrote out this slip in answer to my request for information.

This was not the transformer that I embodied in the relay. I had to make a complete redesign. This data did not serve my purpose. I experimented with the data contained in this memorandum to a very small extent to work out what I wanted.

I have a sheaf of papers here and the first three pages are in my handwriting. They represent some notes which I made for some one; there is no reference here to whom they were sent. The fourth page is in Dr. Dellinger's handwriting, but it is not attached to the first three pages. It is entirely separate. The first three pages of notes were made by me probably for Dr. Dellinger or Mr. Whittemore.

The fifth and sixth pages of this sheaf of papers contain handwriting in black ink and red ink. The black ink portions are in my handwriting, while the red ink portions are in Dr. Dellinger's. The parts of the memorandum that are in my handwriting represent various statuses of different lines of work as they stood on January 14, 1922. The portions written in Dr. Dellinger's hand-

writing represent some suggestions as to how to make some tests and as to the preparation of some papers.

Q. Now, I call your attention to the statement in your handwriting on the sixth page of this memorandum:

"The program of my work prepared by L. E. W. gives an outline of what I am working on."

Who is L. E. W.?

A. L. E. W. is Mr. Whittemore.

Q. Is the program referred to in that memorandum prepared by Mr. Whittemore attached to it?

A. Not what I would call attached; no. It has a paper clip on it.

Q. Well, let me ask you this: Look at the last page of this sheaf of papers and tell me whether that page is the program prepared by Mr. Whittemore, to which you refer? Just answer yes or no.

A. I would have to look at it a few minutes.

Q. Surely, take your time.

A. There is nothing to indicate in my note here that it refers to the particular memorandum attached.

Q. I did not ask you that question.

Mr. HOLTZOFF. I should like to have that question repeated.

(Question repeated by the stenographer as above recorded.)

Mr. HUGHES. I think the answer is responsive, if the court please.

The WITNESS. I had in mind this paragraph.

Q. I am asking you is or is not this last page the program of your work to which you refer in the statement, "The program of my work prepared by L. E. W. gives an outline of what I am working on."

A. I can not say yes or no. There is no indication that this paragraph refers to this particular memorandum. It might refer to some other memorandum.

Q. I am asking you now: Does it or does it not refer to this memorandum?

A. I don't know.

Q. You have seen the last page here before, have you not?

A. I have not any recollection at this time of seeing it; no.

Q. You may have seen it?

A. I may have seen it.

Mr. HOLTZOFF. I offer in evidence the first six pages of this sheaf of papers, and I ask that the last page be marked for identification.

Mr. HUGHES. I do not think the paper has been sufficiently identified, and the offer is not properly made at this time, anyway, if the court please. It all should be offered for identification and proved by the Government. This is a defense witness.

The COURT. Are they in the handwriting of the witness?

Mr. HOLTZOFF. Some are in the handwriting of the witness and some are in the handwriting of Dr. Dellinger, which he has identified. He has not identified the last sheet as yet, and I am not offering it.

The COURT. The objection is overruled.

Mr. HUGHES. Exception, please.

The COURT. Let an exception be entered.

(The first six sheets were received in evidence and marked "Plaintiff's Exhibit No. 63."

The last sheet was received and marked "Plaintiff's Exhibit C for identification.")

Referring to Plaintiff's Exhibit C for identification there is a notation in the lower left-hand corner, "Copy to F. W. Dunmore." This would not mean that I had a copy of this memorandum. It does not mean anything except what it says there. "Copy to F. W. Dunmore." I do not remember any more getting it just from that statement.

Q. I am asking you to go over the matter in your mind and see if that entry does not refresh your recollection on that point?

A. No. It is the subject matter contained which would do that if anything.

Q. Please think quite as hard on this as you did on some of the other questions.

Mr. HUGHES. The question is answered.

A. I do not remember receiving this copy.

Q. When you developed the type B relay, that is the alternating current relay, is it not?

A. Not strictly. It is the type A with the power pack put in.

Q. When you developed the type B relay, you made two pieces of that apparatus for the Signal Corps, did you not, and shipped them out West to the Signal Corps?

A. No.

Q. Did you not have two type B relays made for the Signal Corps?

A. Yes.

Q. You mean you did not make them yourself?

A. That is not what I mean.

Q. What did you mean by saying "No" to my other question?

A. You made two inquiries in one question.

Q. Tell me what the fact was as to the two type B relays that were shipped out to the Signal Corps?

A. I do not remember two relays being shipped to the Signal Corps.

Q. Were there any type B relays delivered to the Signal Corps?
A. There were two delivered to the Signal Corps.
Q. Where were they delivered to the Signal Corps?
A. Downstairs in the radio building.
Q. And where were they made?
A. In the Bureau of Standards.
Q. Under your supervision?
A. At the request of the Signal Corps. Major Mauborgne at that time asked that two be made.
Q. And that request was complied with?
A. Yes.

At one time I prepared specifications that were gotten out by the Bureau of Standards for the type B relay. The specifications were entitled "Relay for Audio Frequency Currents, Type B."

Q. And that document contains a description of the construction and the operation of the type B relay?
A. It describes the type A with the power pack in it.
Q. When you say that it describes the type A with the power pack in it, that is the type B, is it not?
A. That was the name given to it at some later date.
Q. It is the alternating-current relay?
A. It is the relay operated by alternating current; yes.
Q. And this document was prepared by you?
A. Yes.
Q. At the Bureau of Standards?
A. Yes.

The first sheet of the drawings which are attached to this document was apparently prepared by Mr. John P. Buckley, whose initials appear on it. He was a draftsman for the radio section. The second sheet apparently has not been initialed by anyone. It was prepared at the bureau, and so far as I remember, yes; by one of the bureau draftsmen. The first sheet is initialed by me. The drawings show in a general way how to make the type A relay, including the power pack, in a box with the same unit. That would make it the type B relay. It was so designated.

Mr. HOLTZOFF. I offer in evidence the documents and the drawings attached thereto, in reference to which the witness has just testified.

The COURT. They will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 64.")

The WITNESS. I am familiar with a magazine entitled "Electrical World." I remember writing an article which was published in that magazine entitled "Remote Control by Radio Possible." In this

volume of Electrical World that I have here, volume 80, pages 1222 and 1223, for December 2, 1922, is the article to which I have referred. This article is illustrated by two figures. Figure 1 illustrates the type A relay.

Q. Figure 2 illustrates what we have been referring to as the type B relay, does it not?

A. It illustrates the relay that was called type B on December 2, 1921, the date of this article.

Q. Do not let us quibble over words. The alternating-current relay is generally referred to as the type B relay, is it not?

A. It was after a certain date.

Q. And you referred to it by that name in your weekly report cards and in your monthly reports?

A. Not always; no.

Q. But at times you did?

A. Yes.

Q. Therefore, is it not a fact that Figure 2 of this article refers to the type B relay?

A. Yes.

Q. Do you remember a statement in that article in which you state:

"The Bureau of Standards has developed a relay by means of which radio signals can be received and recorded for use to operate a remote-control mechanism."

A. I do not remember making that statement now.

Q. I show you the article.

A. The article says that.

Q. The article says that?

A. Yes.

Q. And you wrote the article?

A. Yes.

Mr. HOLTZOFF. I offer the article in evidence.

Mr. HUGHES. I do not see any objection, but, of course, Mr. Holtzoff makes this witness his witness.

Mr. HOLTZOFF. Oh, no; this is by way of cross-examination.

The COURT. It is admitted without objection.

(Received in evidence and marked "Plaintiff's Exhibit No. 65.")

I can not tell you how the work in developing the receiving set or amplifier operated by alternating current was divided between Mr. Lowell and myself. I can not now say what ideas or features were contributed by Mr. Lowell and what ideas or features were contributed by me. I do not remember.

Mr. Lowell commenced work upon the alternating current receiving set, I think, about December 7th or 8th, 1921. I am sure about that.

Q. Well, now, don't you remember testifying in the interference proceeding:

"I remember the first week in January Mr. Lowell had finished his work on the cross-coil direction finder and started work in earnest on the A. C. operated receiver."

A. I remember that statement.

Q. Was that statement true?

A. Yes.

Q. So that Mr. Lowell did not start working in earnest on the alternating current operated receiver until after the first week in January?

A. By that word "earnest," I meant he started to put one in a box and fix it up in more permanent shape.

Q. The nub of that development was to eliminate the hum, was it not?

A. What development?

Q. The alternating current operated receiver?

A. The claims principally read on that.

Q. And when was the hum eliminated?

A. December 10, 1921, principally.

Q. What do you mean by principally?

A. Satisfactorily.

Q. Then there was not anything left to do after December 10th, except to put the apparatus in a box?

A. The minor details to be taken care of to perfect it, so that it would be more adapted to the residence use in houses.

Q. Do you remember that in the interference proceeding the examiner of interference held that this invention was reduced to practice not later than January 20, 1922?

A. No; I do not remember when he did that. It is recorded. I do not remember, but it is recorded.

Q. I show you a copy of the opinion of the examiner of interferences, and I call your attention to the first full paragraph on page 11, where the examiner says: "Lowell and Dunmore continued to improve their device, and the same was reduced to practice not later than January 20, 1922."

Mr. HUGHES. I ask that that question be stricken out. He is reading from something and we do not know what it is.

The COURT. The objection is overruled.

Mr. HUGHES. May I have an exception, please?

The COURT. Let an exception be entered.

By Mr. HOLTZOFF:

Q. Does this refresh your recollection as to what the examiner of interferences held?

A. No.

The COURT. Are you asking whether that statement is true or untrue?

Mr. HOLTZOFF. I will follow that up.

The WITNESS. It says not later than January 20, 1922.

Q. And is not that statement correct?

A. No; from my idea of it.

Mr. HOLTZOFF. I offer in evidence a copy of the opinion of the examiner of interferences in the interference proceeding entitled Pupin vs. Duncan vs. Lowell and Dunmore, vs. Blatterman, Patent Interference No. 53154, and the date of the opinion being March 19, 1930.

Mr. HUGHES. We object.

The COURT. Objection sustained.

Mr. HOLTZOFF. I respectfully except.

The COURT. Let an exception be entered.

Mr. HOLTZOFF. I am not certain, but it seems to me that as a matter of fact the examiner of interferences is a tribunal, so the court could take judicial notice of those decisions.

The COURT. If that be so, it is in.

Mr. HOLTZOFF. At any event, may I have this opinion marked for identification?

The COURT. Yes.

(Received and marked "Plaintiff's Exhibit D for Identification.")

Mr. HOLTZOFF. You do not object that the copy is not certified, do you, Mr. Hughes?

Mr. HUGHES. No.

Looking at page 49 of my laboratory notebook (plaintiff's Exhibit No. 26), at the entry for December 10, a diagram on that page represents the alternating-current receiving set covered by the patent which has been marked "Plaintiff's Exhibit No. 2, patent No. 1455141." That is the patent on the receiving set.

Q. What kind of a detector is shown on this diagram?

A. We show there a vacuum tube detector, but we had of course been familiar with the use of crystal detectors long before we used vacuum tubes, so that when this circuit was put up we had thought of the crystal in place of the tube.

Q. My question was whether this shows a vacuum-tube detector.

A. Yes; it does.

That is the detector that I tried on that day. The diagrams contained in the patent show a crystal detector. As a matter of fact, there is some such statement in the specification in the patent that it is preferable to use a crystal detector for the purpose of eliminating the hum.

Q. Are you not sure that there is?

A. I do not know whether it is worded just that way, but there is a statement to that effect.

Q. Do you remember this statement in your specification, on page 2 of the patent, line 28:

"We have discovered that this residual hum can be eliminated and in the present receiver the telephones are to all practical purposes, absolutely silent as far as any residual hum from the alternating current power supply is concerned. To obtain this result we employ a rectifier of the crystal-detector type, although other forms of rectifiers may be readily employed interposed in circuit after the stages of radio-frequency amplification and before the stages of audio-frequency amplification. The use of a crystal detector is not as objectionable as it would seem on first consideration, as the radio audio amplification in association with this form of rectifier makes possible a quick adjustment due to the fact that most any point on a sensitive crystal will bring in a signal of sufficient intensity for all practical purposes. The employment of a crystal detector in place of the electron tube detector reduced the 60-cycle hum very considerably. When an electron tube is used as a detector, there is impressed on both the plate and the filament a 60-cycle alternating-current voltage which although small becomes very objectionable when amplified by one or two stages of audio-frequency amplification. When the crystal detector is used, 60-cycle voltage is supplied to the detector current. The radio-frequency transformer whose output is delivered to the detector circuit presents the passage in any appreciable amount of 60-cycle current supply to the radio-frequency stage, and such voltages are not present in the crystal detector circuit, and do not reach the input of the audio-frequency stage."

Q. Do you remember that passage in your specification?

A. These statements are made in the specifications and are not part of the claims. I note here it says:

"To obtain this result we employ a rectifier of the crystal detector type, although other forms of rectifiers may be readily employed."

Q. Is it not a fact that in the months of January and February, 1922, Mr. Lowell, either with or without your cooperation, experimented with the use of a crystal detector and reached the conclusion that the crystal detector was a desirable feature for the purpose of eliminating the hum or aiding in eliminating the hum?

A. That conclusion was in December, when we were using the tube; we naturally had been familiar with crystals for many years and we knew that a crystal in there would naturally be less subject to hum than if you put a tube in as a detector.

Q. I did not ask you when you knew it, but is it not a fact that you experimented with the crystal detector in January and February?

A. Yes; but we had thought of using the crystal on December 10, 1921.

Q. But you did not use it on December 10, 1921?

A. No; we did not use it.

Q. I call your attention to Fig. 1 of this patent——

A. I want to qualify that last statement.

Q. Surely.

A. I do not remember using it.

Q. I call your attention to Fig. 1 of this patent and I ask you if at No. 17—patent No. 1455141—I ask you if No. 17 does not indicate a rheostat which is connected with the radio-frequency section?

A. No; I would not call that a rheostat.

Q. What is that?

A. A potentiometer.

Q. That is one of the hum eliminators that the circuit diagram shows, is it not?

A. Yes.

Q. Will you show me where this potentiometer is indicated in your drawing of December 10th?

Objection by Mr. Hughes.

The COURT. Objection is overruled.

(Exception noted for defendant by direction of the court.)

A. That is easy. Instead of one there are three of them like that. There are four, the first four, beginning left to right.

The drawing of December 10th shows a separate potentiometer for each stage of radio-frequency amplification instead of a single potentiometer for the entire radio-frequency section of the receiving set.

Q. I call your attention to No. 18 in Fig. 1 of that patent and I ask you what that represents?

A. Continuing my other answer, that is merely a multiplicity of the same means.

Q. Is not Fig. 18 a potentiometer connected——

A. I am answering my last question.

Q. Go ahead.

A. May I have the next question?

Q. Does it not represent a potentiometer connected with the audio-frequency portion of the receiving set?

A. Yes.

Q. Is there such a potentiometer in your drawing of December 10th?

A. Yes; two just like it.

Q. You have a separate potentiometer for each stage of audio amplification there, have you not?

A. I have a multiplicity of the same thing.

Q. You have a separate one for each stage?

A. We do.

Q. You and Mr. Lowell have a separate one for each stage?

A. Yes; but we found out——

Q. Now, I ask you to state——

A. I have not finished my answer.

Q. I thought you had.

A. That answer is enough.

Q. Will you refer to Fig. 1 of that patent again and tell me what No. 9–A stands for?

A. That is a condenser.

Q. To what is it connected?

A. It connects from the detector circuit to the filament circuit.

Q. And what does the Fig. 10 stand for?

A. A condenser.

Q. What does that connect?

A. It seems to be across the primary of the first audio transformer, but as I recall it this condenser was not shown or rather was in the circuit of December 10th, while not physically shown, it existed as an electrostatic capacity or a capacity between the circuit, so that we had it there although not physically shown.

Q. It is not shown in the drawing of December 10th?

A. It is shown, radioly speaking, as a capacity between the elements of the tube.

Q. Where is it shown in the drawing?

A. It is difficult to point it out without some way of describing it on paper, but I can point it out. It is shown from the wires right down through here, past the coupling to these wires here, and that constitutes the same kind of thing as shown by condenser 9–A.

Q. How about the condenser 10? Is there any corresponding part?

A. Yes; the same thing as this [indicating].

Q. Where?

A. That condenser 10 is the same thing as this coil here [indicating]. The capacity of the windings of that particular transformer was the same thing, radio speaking, as condenser 10.

Q. You have no condenser corresponding to condenser 10 in your drawing of December 10, have you?

A. It is not shown as two lines, as in the patent drawing, but it exists.

Q. Is it shown as a condenser?

A. It is to me, a radio engineer.

Q. Where is the condenser?

A. Past the coupling, between the coils of the secondary of that transformer.

Q. Isn't that an inductive coupling?

A. It is between the primary and secondary, but not between the turns of one of the coils.

Q. How is the capacity coupling indicated—in what manner?

A. Any coil of wire, one turn being adjacent to its neighbor, has capacity. Any coil of wire has a capacity——

Q. But there is no condenser?

A. It is a condenser; yes.

Q. You mean that an inductance is a condenser?

A. Certainly. Most inductances are also condensers if they have a multiplicity of turns.

Q. But in this drawing you have both an inductance and a condenser instead of an inductance alone, have you not?

A. It is shown more clearly in this drawing.

Q. I am asking you if in the patent drawing you show both a condenser and an inductance, whereas in your drawing of December 10th you show an inductance alone?

A. We represent the capacity in the coil, and bring it out and show it as condenser 10. That is a way of representing it.

Q. And you also show an inductance, don't you?

A. That is the audio transformer.

Q. And in the drawing of December 10 you show the audio transformer, and you show no condenser; is that not true?

A. It is not shown there, no; but it exists.

Q. The condenser as such does not exist, does it?

A. A condenser exists.

Q. You mean the inductance performs the function of the condenser; is that your point?

A. No; inductance is not capacity.

Q. Do you remember receiving for consideration a letter addressed to the Bureau of Standards by the Manufacturers' and Inventors' Electric Company, dated September 30, 1922, inquiring in reference to the relay recorder?

A. No.

Q. Well, I show you a certified copy of the letter in question, and I ask you if that does not refresh your recollection [handing document to witness]? I am only asking you about the first page. I am not asking you about the second page yet.

A. I don't remember this letter; no.

Q. By the way, before we proceed with this, I want to ask you one more question on another point. The apparatus which you and Mr.

Lowell first constructed, the receiving set operated by alternating current, had a crystal detector, did it not?

A. Which apparatus do you mean?

Q. The A. C. receiving set or the A. C. amplifier?

A. The complete one in a box that we finally made at the bureau?

Q. Yes.

A. Yes.

Q. And the box that is at clerk's desk to which I am pointing, is that set?

A. Yes.

Q. And what I am pointing to is the crystal detector [indicating]?

A. Yes.

Q. Will you look at the second page of this sheaf of papers and tell me if that is in your handwriting [handing document to witness]?

A. Although this letter is in my handwriting I never remember writing any such letter as this letter. It states a situation which never existed, in that it says the member who developed it, meaning the relay, applied for letters patent on the same, and there were never any letters patent applied for any type A relay, which was the only type existing on October 7, the date of that letter.

Q. I call your attention to the date of the letter again. It is October 7, 1922, is it not?

A. Yes.

Q. Both types were in existence at that time, were they not?

A. Yes.

Q. So you want to correct your previous answer?

A. Yes.

Q. Now, my question was, whether this paper is in your handwriting; it is, is it not?

A. Yes.

Q. And what does it purport to be?

A. It purports to be a statement about the patent as to a relay.

Q. Is it not a draft of an answer which you prepared in pencil to be sent to the letter from the Manufacturers and Inventors Electric Company, addressed to the Bureau of Standards?

A. I was often made to prepare letters by my chief and not my own letters. They were sent out under my initials many times but they were not prepared by me. They were dictated by me and did not give my views on the matter, and this probably was one like that. I was told to write a letter like this.

Q. It is in your handwriting?

A. Yes; it is in my handwriting.

Q. And this letter in your handwriting says:

"We have received your letter of September 30, 1922, in which you ask for details regarding construction of the relay recorder as developed by this bureau."

That is true, is it not?

A. That is what the letter says.

Mr. HOLTZOFF. I offer in evidence the paper in the witness's handwriting as well as the certified copy of the letter from the Manufacturers and Inventors Electric Company.

Mr. HUGHES. We object. The date is substantially after any of the facts testified to in direct examination or any of the facts relied upon in support of the patent or any of the facts relied upon by the theory of the Government.

Mr. HOLTZOFF. That is offered as an admission against interest to show that the relay was a Bureau of Standards development.

The COURT. Objection overruled.

Mr. HUGHES. Exception.

The COURT. Let an exception be entered.

(Received in evidence and marked "Plaintiff's Exhibit No. 66"; and the Dunmore draft received in evidence and marked "Plaintiff's Exhibit No. 66–A.")

Mr. HOLTZOFF. That is all.

Redirect examination:

Plaintiff's Exhibit No. 62 contains this statement "Drilling one panel and assembling apparatus on panel for radio receiving relay type B on project 42." I do not recall dictating that statement.

My explanation of what that statement is and how it got there is that it was the custom in getting work done in the shop to make a rough pencil note stating what you wanted done and put it in your outgoing tray and it went to the office where the clerk typed it on one of these forms, and apparently in this case the statement "On project 42" must have been added in the office, and when I signed it I overlooked it because the type B relay had the alternating-current feature in it and of course 42 was an Air Service project and there is no alternating current on aeroplanes, so that there is an error somewhere.

It is my testimony that the reference to project 42 there is an error and I do not know how it got there.

Q. I hand you plaintiff's Exhibit No. 65. What is the date of this article?

A. That is dated December 2, 1922.

Q. When you were examined as to this paper my recollection is that you were under the impression that that was dated 1921. On December 2, 1922, the receiving set device had been reduced to practice, had it not?

A. Oh, yes.

The type B relay, the type A relay, and the loud-speaker had all been reduced to practice by December 2, 1922.

In answer to your question as to whether or not on or prior to December 10th I had used both a tube and a crystal detector I would say, as I have previously testified, a crystal detector was one of the most common things in the radio. As to the fact that we used a tube on that day, we knew of course of the crystal, and while I do not recall trying a crystal on that particular day, we used crystals many times. I do not recall whether I had used a crystal on the apparatus before December 10th.

FREDERICK A. KOLSTER, having been duly sworn, was examined and testified as follows:

Direct examination:

I am chief research engineer for the Federal Telegraph Company, of California, and the Kolster Radio Corporation, of Newark, New Jersey. I was at the Bureau of Standards from December, 1912, until about the 1st of March, 1921, a period of about ten years.

I first became engaged in the radio field and radio science in 1902 as assistant to Mr. John Stone Stone at Boston, Mass. My whole life since that time has been spent in the development of radio.

The occasion of my coming to the Bureau of Standards in 1912 was that the Government undertook the problem of regulating radio and making laws for the operation of radio apparatus, particularly on ships. This was due to the fact that radio or wireless, as it was more commonly called in those days, was operated in a very unsatisfactory, disorganized, and chaotic manner; and because of its importance as a means for the protection and safety of life at sea the Government decided to regulate the operation and installation of radio, particularly to enhance its value as a protective means.

The Director of the Bureau of Standards, who at that time was Dr. Samuel W. Stratton, of course, because of this Government activity in radio, desired to obtain some one to come to the bureau to undertake the various problems of radio which would arise, due to this Government-regulation situation, and I was appointed for that position.

The first thing I had to do at the Bureau of Standards was to orient myself and find out what the functions of the bureau really were and what line of work I should put my attention to.

The bureau, as everybody knows, is the national headquarters or the national seat of standardization.

The bureau is where the standard measurement of length, the standard weight, and measures of all kinds are established and maintained.

It was, of course, essential, due to the fact that Congress had prescribed laws on radio specifying the length of wave that should be used by the ship and character of the wave by defining its logarithmic decrement, which is a technical term descriptive of the character of wave transmitted by radio apparatus, and other technical rules of that sort, it was imperative that the Government should have means, and particularly at the Bureau of Standards, of measuring and standardizing these various radio characteristics.

The character of the work done by me while at the Bureau of Standards was fundamentally that of establishing the standard equipment and standard measurement for apparatus and determining the means for making such measurements and establishing standards. Fundamentally, that was the character of the work done in all sections of the bureau.

I was the first man on the job in the radio section. I built up that work in the bureau. I do not recall the exact date that the radio activity of the bureau was given the dignity of some sort of sectional standing, but I think it was just prior to the time when we entered the World War. I remained in charge of the radio work until I severed my connections with the bureau.

I was chief of the radio section, with this exception, that I think during the latter part of my time at the bureau the radio was divided into two sections, and I think they were called sections A and B, and at that time Dr. Dellinger had charge of one of the sections. Up until that time I had been chief of the entire section. I know Mr. Dunmore very well. He was one of my assistants. He worked directly under me. He came to the bureau some time in 1918 and worked under me as long as I was there. I know Mr. Lowell very well. He was the first assistant I had, and he came in shortly after I went to the bureau. I think that it was in 1913 that he came to the bureau. He worked under me continuously until I left. He did not have any other chief while I was there.

(See Kolster testimony under Rule 46 on page 208.)

(No cross-examination.)

JOSEPH O. MAUBORGNE, having been duly sworn, was examined, and testified as follows:

Direct examination:

I am a lieutenant colonel of the Signal Corps of the United States Army. My experience in the radio field has been as follows: I have been connected with radio experimental work and with the radio work of the Army since probably 1900 or 1901. That is to say, my statement covers both those phases of the work.

For a period of years I did a lot of experimental work of my own, and in 1909 I went to the Army Signal School, where I studied communication engineering, including radiotelegraphy.

For several years after that I was an instructor at that school, in radio work particularly.

From that time on I have been connected with the Signal Corps of the Army, being transferred thereto as a captain in 1917, and have been in touch with all the radio engineering features of the Signal Corps since that time.

My duties were as follows during the year 1921: I was in charge of the engineering and research division of the Signal Corps, which is a technical division in the office of the Chief Signal Officer, Washington, D. C. I held that position up to November 30, 1921, when I was sent to Chicago as department signal officer.

I may say that during that year, however, I went to Europe as a technical adviser to the United States delegation to the Interallied Radio Technical Committee Conference in Paris, France, about the 1st of June, returning about the end of September, as I remember it.

In 1921 I had some discussions with persons in authority at the Bureau of Standards relative to work for the Signal Corps. The Bureau of Standards had asked the Signal Corps to give them some work and transfer them money to do the work, particularly in connection with the radio. During that year, I think prior to my trip to France—I am quite sure it was—we transferred to the Bureau of Standards from the Signal Corps appropriation something between $10,000 and $20,000 for the purpose of having the Bureau of Standards carry on certain research work which would accrue to the benefit of the Signal Corps and help us in our development work. I may say that these conferences to which I refer took place at the Bureau of Standards between myself and I believe Dr. Dellinger and possibly at times Mr. Whittemore, his assistant.

This money that I refer to as of that year was sent to the Bureau of Standards without anything being stated in the letter as to the particular problems on which the money was to be spent.

The conferences to which I refer brought out the fact that the Signal Corps of the Army—which by the way was charged with the development of all radio apparatus, not only for the Signal Corps but for the Air Corps and other branches of the service—in fact the entire Army—was desirous of having three problems to which we specifically referred in our conversations carried on by the bureau.

The first of these was the development of a cross-coil direction finder to be used on the ground for the purpose of determining the position of aircraft in flight.

The second problem was the question of the examination of vacuum tubes and vacuum-tube circuits, particularly with reference to determining the characteristics of the tubes and making an examina-

tion of the existing tubes, and in general giving us a better idea of the vacuum-tube art.

The third problem, which was a minor problem, involved the design by the Bureau of Standards of a suitable relay for the use of the Air Corps.

Examining plaintiff's Exhibit 18, paragraph 42, is a section of this paper marked "Radio Projects for the United States Air Service." I may say that these problems were not laid down according to what I see in the paper, those were not the problems given to the Bureau of Standards by the Signal Corps, but by the Air Corps.

But paragraph 42 includes the relay which the Signal Corps was anxious to have developed for the Air Corps in connection with a certain problem which had been in our hands jointly with the Air Corps since the war.

There was at Dayton—where by the way the Signal Corps had a radio laboratory for the joint testing of radio apparatus with the Air Corps—a small airplane which had probably a wing spread of 20 feet to 25 feet. The idea was conceived with a great deal of secrecy, I should say, during the war, that this aircraft would be controlled remotely from another aircraft, and sent through the air, guided, turned to the right or to the left, made to rise or fall, by remote control by radio from another aircraft.

The idea also was conceived that this plane would carry a bomb and at the proper time the bomb would be released from the pilotless airplane, it was to have no pilot in it, and in that way destruction brought about. No thought was given to the idea that such a plane would be controlled from the ground because it was realized that where the activities of this plane might be would be so far out of sight that those on the ground could not make any use of it.

The purpose to be served by a secret signalling system to be used with an Air Service selector relates to the first item under the paragraph which states:

"Devise secret signalling system to use with the Air Service selector."

That problem was not given to the Bureau of Standards by the Signal Corps, but by the Air Corps under this memorandum.

That will require me to explain still a little further about the plane and its mechanism.

Hammond, John Hays Hammond, jr., had already been working with the Navy and the Army, particularly with the Coast Artillery, with reference to the control of torpedoes and boats and it was something like his system which was put in his plane.

It meant that there had to be a selective device to differentiate between signals sent from the ground by a single radio set, for

example—one dot of a certain length or a dash of a certain length might cause the rudder of the plane to turn to the right, and another dash or two dashes might cause it to turn to the left, and so there had to be a selector which would pick out and lock certain mechanism—pick out the right signal to lock certain mechanism to do this control stunt.

The question of devising a secret signal system to use this selector was so that the enemy could not take control of the plane and perhaps turn it upon ourselves and hence the proposal that the Bureau of Standards do for the Air Corps a job of devising some secret signaling system which apparently never has been touched.

The statement "Inspect the Hammond receiving set" had to do with the question of the selective device, because Hammond claimed in his reports before our fortifications board that his device was a secret device which could not be tampered with by the enemy, and therefore the Air Corps by this paragraph asked the Bureau of Standards to inspect this Hammond device.

It is to be noted that that also was not one of the problems which I, so far as representing the Signal Corps, gave to the Bureau of Standards. We were not asking them to do anything about that, because we had our own plans.

The last sentence is: "Seek relay to operate from 10 to 12 times per second on 500 microamperes." That in effect says that what we would like to have for this airplane is a relay capable of making 10 or 12 contacts a second and which will work on as feeble a current as 500 microamperes at the input to the relay.

Our problem had been to find a sensitive enough relay to take these weak radio signals which were received in this little plane and make it operate to control mechanism. A number of relays had been tried, and some of them were giving fair results, but we realized that if the bureau could make something perhaps more sensitive, put more turns on the relay and make it more sensitive, such as a mechanical relay as we see on the front of the Dunmore relay, that something mechanical or perhaps electrical could be devised, and it was not a question of invention, but merely a question of engineering, to devise something which would work on 500 microamperes instead of on a thousand microamperes, and hence it was an engineering problem and not as we saw it one of invention being involved or likely. It was a designing problem. Just what the Signal Corps wanted was this. Here was the practical use. Not only were we concerned with producing a sensitive relay for this plane, but I personally in the laboratory which I had in the Signal Corps office, had been working on several relays, the Bruce relay among others, which were designed for long-range radio reception. We were interested in printing signals received from France from the Bordeaux station and other stations,

and we wanted something still more sensitive if it were possible to get it.

These relays had been used in conjunction with the ordinary radio receiver and plus an amplifier, the output of which was put through this mechanical form of relay and then put on a tape, operated a tape machine. Hence we had two objects in requesting this particular type of relay although there was not any immediate need, that is, any immediate need for this particular apparatus.

The relay which the Signal Corps required and desired and conversed about with the Bureau of Standards, namely, the one covered by project No. 42, did not in any way involve the application of alternating current. All our receiving sets, whether on the ground or in the air, were worked on direct current from storage battery sources. With reference to aircraft, I may say this: The problem of reception in aircraft involves many things. The question of the power supplied on an airplane is a complicated one because of the necessity for having some central storage plant for furnishing heat for the pilot's clothing, for furnishing the landing lights on the plane, and for other purposes.

From the very beginning of our work with radio in aircraft, we had wind-driven generators which provided the power, direct-current generators, which provided the power for the transmitters and also charged the storage batteries which were the source of power for the filament and plate circuits of the receiving sets. In some cases, the receivers were provided with separate little B batteries, as they were called, which furnished the direct current for the plate circuit.

As to alternating current on the use of aircraft, I should like to say this, that even up to the present time, in spite of the fact that for nine years the radio world has had use of the feature of using alternating current on receivers, we never have been able to adapt it for use in aircraft. We still to-day use direct current in spite of the invention of Lowell and Dunmore and others. There is a reason for that. Our aircraft always have the problem of weight and we have always had with us the desire to give the aircraft radio communication in case it should come to the ground. In other words, the source of power for the radio set even if it were only for the receiver, if it is on the ground, must be available, whether the engine is turning over or not.

That limits the problem, therefore, of supply of current to storage batteries. Only in the case, as I see it, of an enormous dirigible could we put on an aircraft a gasoline-driven engine, alternating-current dynamo to supply power so that we might use alternating-current apparatus for reception purposes. That is out of the question on an airplane, for example, to put on a separate power unit with a gasoline-driven engine in order to supply alternating current.

Hence up to to-day, as I have said, we still have direct-current sources for our receiving apparatus.

Neither the Signal Corps nor the Air Service ordered the Bureau of Standards to devise an alternating-current receiving relay under problem 42.

In 1921 I was in charge of all the radio-development work for the Army, in this sense, that the Chief Signal Officer of the Army by regulation issued by the Secretary of War and by law is charged with the development of all radio apparatus for all branches of the Army, whether it is the Air Corps, the Signal Corps, the Coast Artillery, the Field Artillery, or what not.

Inasmuch as I was the right-hand man of the Chief Signal Officer of the Army and directly in control of the activities of initiating developments and seeing that they were carried through by any one of the four laboratories which I controlled, to that extent my answer is "Yes."

Looking at the subheadings under problem 42, the relay work is very remotely connected to the secret signalling system referred to in the first line. That is to say, an entire system would include circuits which really form the secret part of it, plus some sort of an output device, an amplifier and a relay, which is a part of a complete system for producing a control signal. But, nevertheless, those are two distinct phases of this complete set of apparatus. In other words, you might have had a relay of this type in a nonsecret signalling system. The secrecy part of it did not in any way depend upon the character of the relay used or whether you used a relay or not. The secrecy was given by the circuits themselves and not by the relay that was in this system.

Cross-examination:

I am under subpœna here—I was subpœnaed by the defendant in this case.

In the year 1922 the Signal Corps ordered two type B relays from the Bureau of Standards. I can not say exactly from my own knowledge about what part of the year these relays were ordered because the situation was that on November 30, 1921, I went to Chicago and the circumstances surrounding the ordering of these two relays were as follows: I had seen the Dunmore relay at the Bureau of Standards before I turned over my engineering and research job to my successor, Major Bender, prior to November 30, 1921.

I was interested in the possibility of getting a pair of these relays with which to conduct some experiments which I proposed before I left Washington for Fort Hays, Columbus Barracks, Ohio.

I asked Major Bender, who relieved me, if he would not order two relays of the Dunmore type and have them sent to me at Columbus Barracks so that I would be ordered from Chicago, my new station, down to make a test of these things during the coming year, or as fast as the relays were available. The Signal Corps placed an order with the Bureau of Standards for two relays. As I have had occasion recently to inspect that order, I notice they placed in it, for the development of two Dunmore relays of the alternating-current type such as had recently been seen at the Bureau of Standards by Captain Hill and somebody else, indicating therefore that they had seen the complete device before they ordered two alternating-current relays.

Those two relays were sent to Columbus Barracks, Ohio, and I set them up and operated them on alternating current with a view to taking the signals from our Washington transmitter and relaying them to Chicago, and with a second relay taking Chicago signals, relaying through automatically at Columbus to Washington.

I wanted to see how that system would work. We were trying to cut out manual relaying at the intermediate point. To that extent I requested that these relays be made and sent to me, and they were, and I made the test. They were alternating-current relays.

Q. Then would you modify your answer that was given by you, as I understand it, on the examination in chief, that the Signal Corps had no use for alternating-current relays?

A. At the time about which I was speaking we had no use for alternating-current relays because nobody realized then when the $10,000 or $20,000 was placed with the bureau that such a thing could be made.

While it is true that later, after Dunmore and Lowell had developed this, we could find a use for these in our land stations and not on our aircraft, I do not feel that I need to modify the first statement which had reference only to that period when we handed them the money.

My answer that the Signal Corps had no use for alternating-current relays is limited to the time when the money was transferred and prior to the time that a working model had been made by Mr. Dunmore and Mr. Lowell.

After Mr. Lowell or Mr. Dunmore, or both, had developed an alternating-current relay, the Signal Corps found an experimental use for it. Unfortunately the tests were not all that we expected them to be. There was a slight chatter in the relay due to the fact that all the alternating current had not been filtered out correctly. The result was we never did put into use any other, we never since have bought any other Dunmore relays than those two.

PERCIVAL D. LOWELL, having been duly sworn, was examined, and testified as follows:

Direct examination:

My residence is Jamaica, Long Island, and my address is 8553 148th Street.

I was associated with the Bureau of Standards and engaged in the work of calibrating decremeters and wave meters, the measurement of capacity and inductance in the radio section. I became associated with the bureau about January, 1913. My first chief in radio work was Mr. Frederick A. Kolster.

I left the bureau about July, 1922.

Mr. HUGHES. There is stipulated into the record the appointments, promotions, and oaths of office of Percival D. Lowell.

The COURT. Admitted without objection.

(Received in evidence and marked "Defendant's Exhibit No. 9.")

This paper entitled "Probationary Appointment, Department of Commerce, Bureau of Standards," was my first employment authorization card. It was my first appointment to the Bureau of Standards as laboratory apprentice.

Other than the appointment sheets represented here, I did not sign any employment agreements with the Bureau of Standards. I had no other agreement with the Government than the appointments included in this exhibit. I never executed any agreement with the Government respecting patents for any inventions that I might take out.

The official title of the position that I held under my first appointment to the Bureau of Standards was laboratory apprentice. I was assigned as an assistant to Mr. Kolster. He was in charge of the radio work which was being carried on at that time at the bureau. He was the only man who was doing any radio work there at that time.

Q. He was the whole radio work when you got there?

A. Yes, sir; I was the next man on the job.

I would say of my own personal knowledge, at least up to the time that I left the bureau, that the great development of the radio section had been due entirely to Mr. Kolster's efforts. When I first went with the bureau I assisted Mr. Kolster in calibrating decremeters and wave meters and in constructing standards of inductance and capacity, and I had charge of the maintenance of laboratory apparatus such as storage batteries and the like. I made measurements of high frequency resistance of condensers and coils, and I assisted Mr. Kolster in practically all of his direction-finder work.

Mr. Kolster left the bureau about January, 1921. Up to that time I was directly under his supervision.

When Mr. Kolster left the bureau, no change was made with respect to assigning me to any particular section nor no new arrangement as to my work was made. His leaving did not affect me in any way whatever, except that Dr. Dellinger became chief of the laboratory. (See Lowell testimony taken under Rule 46 on page 210.)

So far as I know, the United States does not engage in the manufacture of radio broadcasting receiving apparatus operated by alternating current.

In the fall of 1921 a great majority of my time was being spent in testing a tractor radio compass for the Signal Corps of the Army. I was familiar with Mr. Dunmore's relays, his direct current relay, and his alternating current relay. No one in the bureau ever assigned me to work on either of these relays.

Mr. Dunmore and I completed the invention shown in patent No. 1455141, the receiving set patent, on or about December 10, 1921. The completion of the invention is recorded in Mr. Dunmore's notebook and also on Mr. Dunmore's time card covering that period. Referring to Plaintiff's Exhibit 26—that is, Mr. Dunmore's notebook—the device appearing there covers the invention of the receiving set as of December 10th. It is shown on page 49, under date of December 10th.

Reading from the weekly report card of Mr. Dunmore (Plaintiff's Exhibit No. 24), it is as follows:

"December 10. Made up list of proposed work. Set up a detector and two stages of audio with filaments on A. C. Used stabilizers with center taps going to grids."

This shows the completion of the invention and is a record of the invention of that date.

I cooperated with Mr. Dunmore on the work in the receiving set device mainly by making suggestions here and there. I also cooperated in the testing of the apparatus.

I did not receive any instructions from Dr. Dellinger in December, 1921, or prior thereto, relative to the elimination of batteries in radio broadcast receiving apparatus. I did not have any conversations whatever with Dr. Dellinger in the year 1921 concerning the operation of radio receiving apparatus from alternating current

To the best of my recollection, the earliest date that I ever discussed with Dr. Dellinger the operation of radio receiving apparatus energized by alternating current, the house lighting current, was on or about January 9, 1922. I fix that date because of a memorandum written by me at the request of Dr. Dellinger. The memorandum to which I refer is Plaintiff's Exhibit 20. This memorandum

was prepared at the request of Dr. Dellinger. He asked me for that memorandum in this way. Dr. Dellinger came down to the laboratory one day and inquired what I had been doing, what work I had been doing. He asked me to write a brief memorandum so he might be informed as to what my work had been.

So far as I know, this memorandum was the first information that came to Dr. Dellinger with respect to work on the receiving set device.

Q. What were you working on early in January? That is, what work were you doing in the laboratory early in January of 1922 other than such work as you may have been doing on this apparatus? What was the work to which you were assigned?

A. I was testing an apparatus for measuring the high frequency resistance of inductances and condensers.

Q. That was a measuring job, was it?

A. Absolutely.

Q. Mr. Lowell, subsequent to January 9, 1922—that is, subsequent to the date of your memorandum to Dr. Dellinger on January 9th—there appear on your time cards and your reports entries relating to an alternating current operated radio receiving set. Do you recall those entries?

A. Yes.

Q. To what do they relate?

A. They relate to some work which I did in building up the alternating current amplifier into a complete form, that is, into a cabinet.

The work involved consisted mainly of investigating the various phenomena which occurred and with which we were not entirely familiar. That is, we wanted to find out the best combination we could in order to build it up into a finished receiver.

After January 9, 1922, I did not add anything that was new to the set-up of December 10th. It was all merely a matter of refinement of the circuits which we already used.

I was never assigned by Dr. Dellinger nor anyone else in the Bureau of Standards to work on the electro-dynamic loud speaker, which is the subject of the third patent in this suit.

I remember attending a meeting that was testified to as having been in Mr. Knight's office, at which Dr. Dellinger, Mr. Dunmore, and our lawyers were present.

In reference to this Dr. Dellinger has testified that—

"In the course of the meeting I have a clear recollection that an admission was made by Mr. Lowell or Mr. Dunmore, or both, that the patent had been applied for without informing the bureau because they knew that if they went through that channel a dedication to the public would be required."

I did not make any such admission.

The invention on the loud speaker device was completed on or about January 25, 1922.

I have testified that the invention of the receiving set device was completed on December 10, 1921. On that date the apparatus was in the form of what we call a breadboard model. The apparatus was spread out on a board in a disorderly sort of fashion and wired up roughly. It was not in any sense a compact box model or production model as I would call it.

After the invention is in the form of a breadboard model, to reduce it to commercial practicability there remains to be done just more or less simply engineering developments, as one might call them, which only means more or less a rearrangement in the best possible manner and determining the best values of capacity and inductance and putting them all together in the most compact manner into a finished box.

Cross-examination:

I can not say that I was assigned to one of the groups in 1921 and early in 1922 into which the radio section was divided because I had just kept my individual standing where I had been all the time. To tell the truth, I do not know whether I was working under a group chief or not.

Q. You reported, in so far as you reported to anyone, directly to Dr. Dellinger, did you not, or did you report to some group chief under Dr. Dellinger?

A. I did not report to anybody in particular. I just made out my reports and filed them and left them in the office.

Q. In other words, you worked more or less independently at the time?

A. I think so; yes.

Q. Subject, of course, to Dr. Dellinger's directions or instructions?

A. Yes; I was subject to Dr. Dellinger's directions.

Q. But aside from being subject to Dr. Dellinger's directions, there was no intermediary between you and Dr. Dellinger, am I stating that correctly?

A. That is my understanding of it; yes, sir.

In my report for the month of January, and prior to that, I was working on the high-frequency bridge. That work involved the testing of an apparatus which had already been set up by somebody else designed for the purpose of measuring the high-frequency resistance. I was just testing that apparatus. I made various tests of it over a period of time.

Q. Do you remember the statement in your report for the period beginning November 15th and ending December 15, 1921:

"Some work was done on the high-frequency bridge set, but to date the problem has not been satisfactorily solved."

Do you remember that statement in your report?

A. Yes, sir.

Q. What was the problem that had not been satisfactorily solved up to December 15, 1921?

A. The problem, as I understood it, and as I was connected with it, was to make various tests with the apparatus to determine whether or not satisfactory and correct measurements of high frequency could be made.

Q. If it were found that the apparatus was not satisfactory, what would be the next step to be undertaken?

A. I would say it would be the conducting of various continued tests.

Q. But if the continued tests showed that the apparatus was not satisfactory, what was the next step?

A. Are you referring to what I did, Mr. Holtzoff?

Q. I am referring to what was the problem before you.

A. The problem was to find out whether or not satisfactory high-frequency measurements could be made with the apparatus.

Q. And if you had found that they could not be, then was the problem solved, or was there something more to be done to solve the problem?

A. If it did not work satisfactorily, I would not think it was solved.

Q. What more were you to do to solve the problem if the apparatus did not work satisfactorily?

A. I might make some slight rearrangement of the units, or change a wire here and there, and test again to see if there was any improvement.

Q. You would try to improve the apparatus so that it would be satisfactory, would you not?

A. Why, yes.

Q. You kept making changes in that apparatus from time to time while you were working on the problem, did you not?

A. Yes; I did make some changes on it.

Q. And finally you got a satisfactory apparatus that worked satisfactorily, or didn't you ever succeed in getting it?

A. I do not think it ever was satisfactory, because, as I recollect, the problem was abandoned later on, so apparently it did not work satisfactorily.

Q. But while you were working on the problem you made various changes in the apparatus, and tested it again to see if it would work satisfactorily?

A. Yes.

Q. And finally you reached the conclusion that this particular kind of apparatus or this particular piece of apparatus would not work satisfactorily. Am I stating the fact correctly?

A. I have forgotten whether I considered it satisfactory or not.

Q. When did you finish, or when did you abandon the work?

A. I cannot tell you exactly without referring, perhaps, to some records.

Q. I would be very glad to have you refer to anything you please. I do not want the exact date, but the approximate period.

A. I would say some time in the first part of January, 1921. That is only approximate.

Q. You meant 1922, did you not?

A. Yes. After the first part of January, 1922, for the next month or two I worked on the job of assembling and constructing a finished alternating current operated receiver, perhaps the very one which is in evidence here. I devoted most of my time for the next month or two on that job and also on working out a loud speaker operated in similar manner to be connected with the receiving set.

ROY E. SWENEY, having been duly sworn, was examined, and testified as follows:

Direct examination:

I am treasurer of the Dubilier Condenser Corporation. It is a part of my duties to be familiar with the accounts and expenditures, and the records in that regard, of the Dubilier Corporation.

Q. It is in evidence in this case that the defendant corporation acquired rights under the Lowell and Dunmore patents by an agreement of October 20, 1924. Will you tell the court what has been done by the defendant corporation in the way of exploitation and commercialization of the patents covered by the agreement of October, 1924, in this suit?

Mr. HOLTZOFF. I do not see how that is relevant, and I therefore object, if your honor please.

The COURT. With the greatest doubts, I overrule the objection. Proceed.

Mr. HOLTZOFF. May I have an exception?

The COURT. Let an exception be entered.

A. There has been a great deal of development work done in connection with this and exploitation of these patents and devices under this patent.

The particular or special product made under these patents by the defendant corporation is known under the trade name of the Super-Ducon.

Q. Do you know approximately what sums were expended in the production and the commercialization and the distribution of this product by the defendant corporation?

Mr. HOLTZOFF. May it be understood that this is all subject to my objection, so that I shall not have to repeat my objection to each question?

The COURT. Certainly. Each question is objected to, and an exception entered.

A. There was upwards of $300,000 spent in connection with this development and exploitation work.

Q. Did part of that expense involve the advertisement of the product?

A. Yes, sir.

Q. Through what medium was the advertisement of this product made?

A. Through various trade magazines and newspapers.

Q. Do you know roughly what sums have been spent by the defendant corporation in litigation over these patents and in its attempt to sustain the validity of them?

A. Upwards of $70,000 up to this time.

Q. While the defendant was manufacturing the Super-Ducon and advertising it in papers and trade journals, as I think you testified, did any officials of the Government notify the defendant corporation that it, the United States Government, was the owner of these patents or claimed to be?

Mr. HOLTZOFF. I object to that question as incompetent and having no bearing upon the issues.

The COURT. The objection is overruled.

Mr. HOLTZOFF. May I have an exception?

The COURT. An exception will be noted.

A. No; not to the best of my knowledge. There is nothing in the corporate files to that effect.

By Mr. BERL:

Q. You mean there is nothing in the corporate files to show that such a notice was given to the defendant corporation?

A. Yes.

Cross-examination:

I know Percival D. Lowell and Francis W. Dunmore.

Q. You knew all the time that Mr. Dunmore was an employee of the Bureau of Standards, did you not?

Mr. BERL. I object. I do not think there is anything in the direct examination to call for a question of this sort.

The COURT. The objection is overruled.

Mr. BERL. Exception.

The COURT. Let an exception be entered.

A. Well, I have heard of that, but I have not known Mr. Lowell and Mr. Dunmore hardly long enough to recall any of their connections.

I have been connected with the Dubilier Condenser Corporation since 1926. I did not negotiate the licenses that the Dubilier Condenser Corporation obtained from Mr. Lowell and Mr. Dunmore. That was done prior to my time.

Mr. HOLTZOFF. If your honor please, I move to strike out so much of this witness's direct testimony as states that the defendant received no notice from the United States as to its interest in the patents, because it now appears that the transactions between Lowell and Dunmore and the Dubilier Condenser Corporation took place before this witness became connected with the defendant company, and obviously anything he might say on that point is the purest kind of hearsay.

The COURT. Under cross-examination you have developed the fact that he was connected with the company only since 1926.

Mr. HOLTZOFF. Yes. And he also just testified that the negotiations between Lowell and Dunmore on the one hand and the Dubilier Condenser Corporation on the other took place before he joined the company.

The COURT. Could not a notice have been served on his company after he joined?

Mr. HOLTZOFF. It might have. But it also might have been served before, without his knowing anything about it.

The COURT. That weakness in his statement you have already brought out.

JOSEPH I. McMULLEN, having been duly sworn was examined, and testified as follows:

Direct examination:

I am an officer of the United States Army, lieutenant-colonel and judge advocate. I have been in the Army 34½ years. I am chief of the central patent section of the War Department, and my position corresponds in an industrial concern to chief counsel on patent matters. I supervise all the patent work of the War Department.

Examining paragraph or project 42 of plaintiff's Exhibit 18, I can say that I am acquainted with the work called for by that project in a certain way. All the development and research work in the War Department which involves contracts or transfer of appropriations and so forth has passed through my office for the past eleven

years. The appropriation for the development of that project came from the War Department. My recollection is that that authorization passed through my hands.

As the money appropriated for this project came from the War Department, that meant that the expenses of the project in the Bureau of Standards, including the salaries of the Bureau of Standards men, was paid from that money.

Looking at defendant's Exhibit No. 3, I can say that I am familiar with it and that I saw the original of this instrument some time in 1926. I think I dictated it but I could not say that positively, but it is my recollection that I did dictate a license in 1922, some time between the 9th of April and the 28th of May, I dictated a license from Lowell and Dunmore to the Government on that particular application or patent.

The original license was sent to the War Department—there should be some correspondence to cover that—either by the Department of Commerce or the Department of Justice and comment on our recommendation as to whether that license should be accepted. I dictated a letter over the signature of the Secretary of War, either to the Secretary of Commerce or to the Attorney General.

By Mr. HUGHES:

Q. I ask you to examine this instrument. Do you recognize this instrument?

A. Yes, sir.

Q. What is that a carbon copy of?

A. That is a carbon copy of a letter I dictated on March 8, 1926, for the signature of the Secretary of War and which he signed on March 9, 1926.

Q. And it is addressed to whom?

A. The Secretary of Commerce.

Mr. HUGHES. I offer this letter in evidence.

Mr. HOLTZOFF. I object to it as incompetent, irrelevant, and immaterial and not binding upon the plaintiff. This is a letter from one Government official to another recommending that a certain course be taken which course was not afterwards taken. What bearing has that got upon the issues in this case? I submit none.

Mr. HUGHES. I would like to ask two or three preliminary questions.

The COURT. You are withholding the tender?

Mr. HUGHES. Yes, sir.

Q. The funds that were appropriated by the War Department, under whose jurisdiction did those funds remain?

A. The War Department.

Q. Who was responsible for the expenditure of those funds?

A. Indirectly the Secretary of War is responsible for all the funds appropriated to the War Department but directly they go down by steps. In this case it was the Chief of Air Service. Ultimately, of course, it goes down to the man who actually spends the money, but there is a responsibility all the way up the line or all the way down the line, whichever way you take it.

Q. When money is appropriated by the War Department to some other branch of the service, for work to be done for the War Department, whose work is that?

A. It is the War Department's work. However, it is not appropriated to another department. It is what we call allocated.

Q. The work remains the work of the War Department?

A. Yes.

Q. When funds were allocated to the Bureau of Standards for work to be done on project 42, which you have examined, whose project was that; what department's project was that?

A. The War Department.

Mr. HOLTZOFF. May I correct you, Mr. Hughes. Do you claim that this license that was tendered relates to any matter in project 42?

Mr. HUGHES. I am not claiming that at all. I am claiming that a license was offered for these patents.

Mr. HOLTZOFF. This only covers one patent.

Mr. HUGHES. Yes.

Mr. HOLTZOFF. Which we do not claim comes under 42.

Mr. HUGHES. That is the only one you ever asked for.

Mr. HOLTZOFF. It does not come under project 42. I think there is a little confusion in the testimony.

Mr. HUGHES. I do not think so.

The COURT. What is your position? I do not get it.

Mr. HOLTZOFF. My position is this: That the license that was tendered, which is marked "Defendant's Exhibit No. 3," on its face purports to cover only patent No. 1455141, which is the patent on the alternating-current receiving set, whereas——

The COURT. Had the War Department any interest in that particular patent?

Mr. HOLTZOFF. Oh, no. The War Department funds were transferred on the relay project and so there is some confusion.

By Mr. HUGHES:

Q. The work done on project 42 was done by the Bureau of Standards for the War Department?

A. Yes, sir.

Mr. HUGHES. I renew this offer, if the court please. Here is a statement by the Secretary of War, whose work this was, whose position it was to raise any question of what his work was, whether it covered the relay B or relay A, both or one.

Mr. HOLTZOFF. I object to the introduction of this letter from the Secretary of War to the Secretary of Commerce on two grounds: First, that it is a recommendation from one member of the Cabinet to another member of the Cabinet as to a certain course of action that should be taken which the addressee of the letter apparently did not accept and what one Government official recommends to another is not binding upon the Government any more than if the vice president of a company sends a letter to a president of the company recommending that the president take certain action and the latter adopts an opposite course. Surely I would not be permitted to introduce that letter. That is my first objection.

My second objection is that the letter on its face purports to relate to the alternating-current receiving set because the number of the patent is mentioned in the letter, and that did not come under the jurisdiction of the War Department because the only work in this connection that came under the partial jurisdiction of the War Department was the relay work which was paid for by the Air Service funds, and this was paid by the Bureau of Standards funds, as the testimony shows.

The COURT. I think that is a request and a suggestion that has no binding effect whatever. On the first ground I sustain the objection.

Mr. HUGHES. May I have an exception?

The COURT. Certainly.

The WITNESS. I have here a letter from the Department of Justice. I have seen it before. It was referred to my chief assistant, Major Hill, on February 15, 1926, by the Assistant Secretary of War. The recipient was the Secretary of War.

Mr. HUGHES. Now I offer this letter in evidence.

Mr. HOLTZOFF. I object on the ground that it is a letter from one Government official to another in an endeavor to ascertain what course the Government should pursue.

The COURT. The objection is sustained.

Mr. HUGHES. May I have an exception, please?

The COURT. Let an exception be noted.

The WITNESS. I have another document here certified to by the Secretary of War which I recognize as a letter that I dictated. It is from the War Department to the Attorney General.

Mr. HUGHES. I offer this instrument in evidence, if the court please.

Mr. HOLTZOFF. I interpose the same objection.

(Objection sustained. Exception noted for defendant by direction of the court.)

By Mr. HUGHES:

Q. Now, Colonel, did the War Department tell the Bureau of Standards to get contracts with employees for title to patents that might be taken out for any work done for the War Department?

Mr. HOLTZOFF. I object to that question as incompetent under your honor's ruling.

(Objection sustained. Exception noted for defendant by direction of the court. See McMullen testimony taken under Rule 46 on page 211.)

By Mr. HUGHES:

Q. Was the Bureau of Standards ever authorized by the War Department to secure anything but a nonexclusive license on the relay device?

Mr. HOLTZOFF. The same objection, if your honor please.

(Objection sustained. Exception noted for defendant by direction of the court.)

Q. Did the Government have any use for anything other than a nonexclusive license on the type B relay devised by Mr. Dunmore?

Mr. HOLTZOFF. I object on the same ground as heretofore, and also on the further ground that this witness has not been qualified to answer that particular question.

(Objection sustained. Exception noted for defendant by direction of the court.)

A. I am a member and secretary of the Interdepartmental Patent Board in Washington. I am acquainted with the regulations of the War Department dealing with the taking out of patents by employes.

By Mr. HUGHES:

Q. I hand you this document and ask you if you recognize this document?

The COURT. Are these the regulations that you are speaking of?

Mr. HUGHES. Army regulations.

A. Yes.

Q. Who drafted that?

A. I did.

Mr. HUGHES. I offer them in evidence.

Mr. HOLTZOFF. I object to the introduction of the regulations.

The COURT. Objection sustained.

The WITNESS. On projects paid for by the War Department the method of accounting for those funds is this: The funds, if they are allocated to any other branch of the Government, or other department of the Government than the War Department or to any other

branch of the War Department than the one to which they were appropriated, for instance, if they were allocated to the Signal Corps and appropriated to the Air Service, they are accounted for as far as bookkeeping is concerned, by the department who spends them. But they are spent under the direction and accounted for to Congress by the party to whom they were appropriated, like the War Department. Just before the World War we installed a new system of expending money. We have what we call agencies. Any disbursing officer or any department head or bureau head may appoint an agent to expend the money for his department. He may require the agent to furnish a bond, but where it is from one department to another they do not require a bond.

The disbursing officer gives me personally money to expend and if it is a large sum he requires a bond and otherwise I merely do it as his agent and the entire thing is agent's operation which we never had before the World War.

By the COURT:

Q. Do you account to Congress for the appropriation?

A. Absolutely, and the appropriation can not be spent for anything except for what it was intended for before the committees in Congress. Some of the appropriations of course, like an appropriation for what they call research and development work, can be spent in the broad field of research and development, we will say, for radio or for airplanes or for this, that, and the other, but you can not go outside of the field.

Mr. HUGHES. I think the Army regulations therefore are entirely pertinent to the status of this case.

Mr. HOLTZOFF. I object to the introduction of the Army regulations on two grounds, first, that these employees were employees of the Bureau of Standards and not employees of the War Department, and the regulations specifically apply, I take it, to the employees of the War Department.

I object also on the further ground that whether or no these patents belong to the Government is a question of law, and suppose the War Department, or any other department of the Government, issued a regulation permitting the inventors in the Government service, who make inventions as part of their duty, to retain title to the inventions. My contention then would be that has no bearing upon the case because such a regulation would be ultra vires and illegal, as was held in the Houghton case.

By the COURT:

Q. You do not contend that these two gentlemen are your employees, Mr. Dunmore and Mr. Lowell? They are not employees of the War Department in the execution of this project?

A. For the time being they were. If I may explain to your honor, I have a rather large project under my control. I borrow people from the Bureau of Standards who are for the time being my employees. That is, I pay them out of my appropriations to go to Europe and make researches for me, or to San Francisco and Seattle, and for the time being all these employees are carried on a roll paid out of War Department funds, and it works this way:

When a man is on the Bureau of Standards roll as a regular Bureau of Standards employee, when they begin to pay him out of the War Department funds, he is transferred to a War Department appropriation roll. He may be carried on the roll of the Bureau of Standards, but it is under the heading "War Department Funds." The record has to be complete. Every civilian employee's record has to be complete as to what appropriation he is paid out of, but the actual roll of these two gentlemen was not necessarily always that of the Bureau of Standards.

Q. Did you ever have them on your rolls in the War Department?

A. Not in my office. I do not know whether your honor gets me exactly. They carry them on their rolls. All the rolls are exactly the same. A Bureau of Standards pay roll is not any different from the War Department pay roll, but they carry them under the heading of the War Department appropriation or bureau appropriation, and when I have Bureau of Standards employees, I do not have them actually on my roll in my office, but they are carried on the roll in their office under the War Department head, or if they have my employees in their office, I carry them on my roll under the head of the Bureau of Standards.

(Objection sustained on both grounds. Exception noted for defendant by direction of the court.)

Q. Referring now to project 42, relay for bombing control. Are you acquainted with what that project called for?

A. In general, yes.

Q. Would a relay operated by alternating current have been of any service under that project?

A. None at all.

Mr. HOLTZOFF. I move to strike out the answer because this witness has not been qualified.

(Objection overruled. Exception noted for plaintiff by direction of the court.)

No cross-examination.

Mr. HUGHES. If the court please, I offer in evidence Defendant's Exhibit A for identification, the weekly time card of Mr. Whittemore for December 12th to 17th, 1921.

(Received in evidence and marked "Defendant's Exhibit No. 10.")

Mr. HUGHES. I also offer in evidence the weekly time card of Dr. Dellinger for December 12th to 17th, 1921.

(Received in evidence and marked "Defendant's Exhibit No. 11.")

Mr. HUGHES. I also offer in evidence Dr. Dellinger's weekly time card for December 24th to 31st, 1921.

(Received in evidence and marked "Defendant's Exhibit No. 12.")

Mr. HUGHES. I also offer in evidence Defendant's Exhibits E and F for identification, the annual reports of the Bureau of Standards for the years 1921 and 1922.

(Received in evidence and marked "Defendant's Exhibits Nos. 13 and 14.")

Mr. HUGHES. If the court please, I offer in evidence patent of P. R. Heyl, No. 1660751.

Mr. HOLTZOFF. I object on the ground heretofore stated.

(Objection sustained. Exception noted for defendant by direction of the court.)

Mr. HOLTZOFF. I offer in evidence the alternating-current amplifier.

(Received in evidence and marked "Plaintiff's Exhibit No. 67.")

Mr. HOLTZOFF. I offer in evidence the rectifier unit which accompanies the alternating-current amplifier.

The COURT. That is the receiving set?

Mr. HOLTZOFF. Yes; it is popularly known as a receiving set.

The COURT. It will be admitted in evidence.

(Received in evidence and marked "Plaintiff's Exhibit No. 67-A.")

Mr. HOLTZOFF. I offer in evidence the type B relay.

The COURT. It will be admitted.

(Received in evidence and marked "Plaintiff's Exhibit No. 68.")

Mr. HUGHES. If the court please, I should like to ask one or two questions:

Are these the devices as they came from the Bureau of Standards?

Mr. HOLTZOFF. Yes.

Mr. HUGHES. They have been at some other place in the meantime?

Mr. HOLTZOFF. Yes; they have been in the Patent Office in the meantime, because the Bureau of Standards permitted Lowell and Dunmore to withdraw them for the purpose of using them in the interference proceedings.

We obtained them from the Patent Office for production in this court.

The COURT. Have the patentees seen these in their present condition?

Mr. HUGHES. If the court please, I think they are probably in the same condition.

I think the statement of the whereabouts of these instruments and how they come to be here ought to be made a matter of record in this case.

Mr. HOLTZOFF. Yes; I made the statement on the record.

The COURT. Do those instruments fairly represent the work of the patentees?

Mr. BRADY. Yes; those are the exhibits from the interference division, sir.

Mr. HUGHES. If your honor please, we close our case.

Defendant rests.

Mr. HOLTZOFF. There will be no rebuttal.

Appendix showing the testimony taken in behalf of the Appellee under Equity Rule 46

Direct examination of Francis W. Dunmore, a witness in behalf of appellee:

Q. Did Dr. F. A. Kolster tell you anything about patents or inventions?

A. Yes; I had several discussions with him in regard to patents. He told me that he had taken out several, and that it was proper to take them out, provided the Government was given a nonexclusive license under them.

(The foregoing testimony was taken at the stage of the trial recorded on page 149 of this record.)

Direct examination of Dr. Frederick A. Kolster, a witness in behalf of appellee:

Q. Were you during your connection with the bureau ever instructed that the results of the bureau's activities must not be restricted by patent?

A. We never received any instructions of that kind.

Q. Did you receive any instructions whatever about the patenting of work done in the bureau?

A. None at all.

Q. Did anybody in the bureau ever give you to understand that the United States Government wanted anything other than nonexclusive or shop rights to patents: that is, the right to use and manufacture without paying royalties?

A. I think it was understood by the employees of the bureau, or at least my section and myself, that the Government was entitled, or any bureau of the Government or any department of the Govern-

ment was entitled, to the full benefits of any invention if one was made or any device invented by these employees.

The instruments which you hand me are United States letters patent on radio apparatus invented by myself during the period of time when I was in the Bureau of Standards. The work reflected in those patents was done by me at the Bureau of Standards. I recognize the scientific paper of the Bureau of Standards, F. W. Stratton, Director, No. 428, which you hand me. The substance of the article contained in that paper cover is one of the standard types of scientific paper published by the Bureau of Standards. This particular one, No. 428, is under the authorship of myself and Mr. Dunmore and is entitled "Radio Direction Finder and Its Application to Navigation."

It is a scientific paper whose purpose is to show what can be done by radio and how radio may be used in determining the direction of radio signals, as, for example, bearing of a lighthouse by the navigator on board ship, by way of radio signals and a radio direction finder. That device is now used in a number of Government departments—the Navy, the Coast Guard Service, and the Army. Many of the Army transports are equipped with these devices.

I took those patents out at my own expense. Dr. Stratton was the director of the bureau at the time I took those patents out. I had no discussion with him with reference to any of the patents taken out by me except with respect to one of them—I think the early one. I did have a discussion with him on this particular application, because it was of special interest to the Navy Department. The Navy Department requested the bureau to maintain a certain secrecy with respect to this device because of its military importance. The discussion with Dr. Stratton was with relation to that matter. I maintained the secrecy requested by the Navy Department. The Navy Department entered into a contract with me and paid me a certain sum of money for keeping this device under secrecy for a definite period and not putting it to practical use.

(There were thereupon introduced in evidence under rule 46 the patents above referred to under the designations "Defendant's Exhibits A, B, C, and D under rule 46" and the scientific pamphlet entitled "Scientific Papers of the Bureau of Standards No. 428" under the designation E. The said exhibits are made physical exhibits by stipulation.)

Q. Dr. Kolster, the patents which you have just discussed, and which are now in evidence in the scientific paper—I will ask you whether the subject matter of the scientific paper covers the subject matter of the patents?

A. Only in a general way. It was simply a description of the method of using radio for the determination of direction and for the promotion of safety at sea. It is not especially a description of apparatus but it is a description or an outline of a method of using something and not of a particular piece of apparatus.

Q. Dr. Kolster, have you dedicated these patents to the public?

A. Every and all departments of the Government are privileged to make use of this, as they have for many years—the Army and Navy and the Coast Guard and the Bureau of Lighthouses—all of the departments which have occasion to make use of a thing of this sort have a right to use them. They have a nonexclusive right, but I have maintained title to them. I have never assigned them to the United States Government by formal assignment.

I do not recall ever having instructed Mr. Dunmore concerning the taking out of patents, but I do recall having discussed the matter with him on some occasions. I think, as I recall, I even had discussions with him working under my direction in connection with this matter of patenting. There has been expression of views for a great many years from the Government in connection with the dedication of a patent to the public. Personally, I have never known exactly what meaning there is to that expression and I have always encouraged and suggested to my men that they should take out patents without this dedication so long as all of the departments of the Government were privileged to make use of the invented device. The best way to deprive the public of an invention is to dedicate it to the public.

I had like discussions with Mr. Lowell.

Q. In your former answer when you said that you had discussions about patents with your men, was Dunmore one of such men?

A. Yes.

Q. And Mr. Lowell?

A. Yes.

(The foregoing testimony was taken at the stage of the trial recorded on page 186 of this record.)

Direct examination of Percival D. Lowell, a witness in behalf of appellee:

I had discussions with Mr. Kolster on the subject of patents. I remember distinctly several discussions on different occasions with Mr. Kolster in which he told me it was perfectly all right to take out any patents on inventions, provided, however, the Government was given the free license. He even went to his private attorney at one time to have a search made for me on something which I had done and which I thought was of a patentable nature.

Q. Prior to March 27, 1922, Mr. Lowell, did Dr. Dellinger ever tell you that you must dedicate any patents for inventions you might make to the public?

A. No, sir; he did not. Nor did he prior to March 27, 1922, ever tell me that I must assign any patents for inventions I might make to the Government. Prior to March 27, 1922, no one ever told me that patents which I might obtain for my inventions would become the exclusive use of the United States Government. No one ever gave me any reason why the Government would be interested in an exclusive license under patents for any inventions I might make.

(The foregoing testimony was taken at the stage of the trial recorded on page 194 of this record.)

Direct examination of Lt. Col. Joseph I. McMullen:

There was introduced as Exhibit F under rule 46 a certified copy of a letter from the Secretary of War to the Secretary of Commerce, dated March 9, 1926, memorandum from the office of the Judge Advocate General to the Secretary of War, dated March 8, 1926, a form of license accompanying the above letter, all of which are made physical exhibits by stipulation.

There was also introduced as Exhibit G under rule 46 a certified copy of a letter from the Attorney General to the Secretary of War, dated February 6, 1922, made a physical exhibit by stipulation.

There was also introduced as Exhibit H under rule 46 a certified copy of a letter from the Assistant Secretary of War to the Attorney General, dated March 4, 1926, which is also made a physical exhibit by stipulation.

Q. Now, Colonel, did the War Department tell the Bureau of Standards to get contracts with employees for title to patents that might be taken out for any work done for the War Department?

A. It did not.

Q. Was the Bureau of Standards ever authorized by the War Department to secure anything but a nonexclusive license on the relay device?

A. No.

Q. Did the Government have any use for anything other than a nonexclusive license on the type B relay devised by Mr. Dunmore?

A. No.

(The foregoing testimony was taken at the stage of the trial recorded on page 204 of this record.)

There was thereupon introduced in evidence under rule 46, under the designation "Defendant's Exhibit I," General Orders, No. 23, War Department, dated June 14, 1921, which is made a physical exhibit by stipulation.

The following stipulation was entered into in open court with respect to the following matters under rule 46:

Stipulation

Mr. HUGHES. To shorten the record in the above stated causes, and for the purpose of said causes only, it is stipulated and agreed by and between the above-named plaintiff and the above-named defendant, respectively, subject, however, to plaintiff's objection as to the materiality of such evidence:

1. That Burten McCollum was an employe of the Bureau of Standards from about 1911 to about 1924; that while such an employe he made certain alleged inventions; that attached hereto and numbered as follows are the copies of patents issued on said inventions:

984582, Feb. 21, 1911. Alternating current motor.

1031802, July 9, 1912. Hysteresis starting device for induction motors.

1035373, Aug. 13, 1912. Alternating current induction motor.

1038775, Sept. 17, 1912. Induction motor.

1044217, Nov. 12, 1912. Squirrel-cage motor.

1095586, May 5, 1914. Alternating current motor.

1156364, Oct. 12, 1915. Induction motor.

1226091, May 15, 1917. Alternating current induction motor.

Re. 17242, March 19, 1929. Method and apparatus for determining the contour of subterranean strata.

1724495, Aug. 13, 1929. Method and apparatus for determining the slope of subsurface rock boundaries.

1724720, Aug. 13, 1929. Method and apparatus for studying subsurface contours.

2. That Herbert B. Brooks was an employe of the Bureau of Standards from about 1912 to the present time; that while such employe he made a certain alleged invention; that attached hereto is a copy of the patent No. 1357197, issued October 26, 1920, covering said invention and entitled "Electric transformer"; and that the said Herbert B. Brooks, while an employe of the Bureau of Standards, was the author of two certain scientific papers entitled "Testing Potential Transformers" (Scientific Paper No. 217) and "A Variable Self and Mutual Inductor" (Scientific Paper No. 290).

3. That William W. Coblentz was an employe of the Bureau of Standards from about 1913 to the present; that while such employe he made certain alleged inventions; that copies of said patents, attached hereto, were issued and numbered as follows:

1418362, issued June 6, 1922; subject, "Electrical resistance."

1450061, issued March 27, 1923; subject, "Optical method for producing pulsating electric current."

1458165, issued June 12, 1923; subject, "System of electrical control."

1563557, issued December 1, 1925; subject, "Optical means for rectifying alternating currents."

And that the said William W. Coblentz was the author of two scientific papers of the Bureau of Standards entitled "Positive and Negative Photoelectrical Properties of Molybdenite and Several Other Substances" (Scientific Paper No. 308) and "Some Optical and Photoelectric Properties of Molybdenite" (Scientific Paper No. 338).

4. That August Hund was an employe of the Bureau of Standards from about 1922 to 1927 or 1928; that while such employe he made certain inventions and took out letters patent thereon, copies of which are attached hereto numbered as follows:

1688714, October 23, 1928. Piezo electric crystal apparatus.

1688713, October 23, 1928. Piezo electric oscillator system.

1649828, November 22, 1927. Method of preparing piezo electric plates.

1648689, November 8, 1927. Condenser transmitter.

And that said August Hund was the author of two Bureau of Standards scientific papers entitled "Note A Piezo-Electric Generator for Audio-Frequencies" (Research Paper No. 40) and "Generator for Audio Currents of Adjustable Frequency With Piezo-Electric Stabilization" (Scientific Paper No. 569).

5. That Percival D. Lowell was an employe of the Bureau of Standards from about 1913 to the middle of 1922; that while such employe he made certain alleged inventions and took out letters patent thereon numbered, respectively:

1439562, December 19, 1922. Amplifying system.

1439563, December 19, 1922. Radio-frequency transformer.

And that said Percival D. Lowell, while an employe of the Bureau of Standards, was the author of a Bureau of Standards scientific paper entitled "Radio Frequency Amplifiers" (Scientific Paper No. 449).

6. That L. B. Tuckerman, G. H. Keulegan, and H. N. Eaton were employes of the Bureau of Standards in October, 1926; that while such employes they made an invention and took out a patent thereon from the United States Patent Office No. 1723636, issued August 6, 1929, for a measuring instrument; and while so employed were the authors of a certain scientific paper of the Bureau of Standards entitled "A Fabric Tension Meter for Use on Aircraft" (Technologic Paper No. 320).

7. That Paul R. Heyl and Lyman J. Briggs were employes of the Bureau of Standards in January, 1922; while such employes they made certain alleged inventions for which they secured United States Patent No. 1660751, dated February 28, 1928, entitled "Inductor Compass"; and foreign patents as follows:

British 184773, dated October 3, 1923.

German 424287, issued April 26, 1922; and that Commercial Standards Monthly is a publication of the Bureau of Standards, and that an article entitled "Instruments to Increase Efficiency and Safety of Aviation Developed by Federal Specialists," written by Henry D. Hubbard, assistant to the Director of the Bureau of Standards, appears on pages 256 to 258, inclusive, of the issue of February, 1930, Volume VI, No. 8, thereof; and that Paul R. Heyl and Lyman J. Briggs wrote an article on the earth inductor compass appearing in the proceedings of the American Philosophical Society for 1922 in Volume LXI, No. 1, pages 15 to 32; that the article on page 795 of Mechanical Engineering, dated October, 1925, entitled "Earth Induction Compass," was written by George P. Luckey, of Dayton, Ohio, engineering division, Air Service, McCook Field; that in Report No. 128, Aeronautic Instruments, issued by the National Advisory Committee for Aeronautics, dated 1925, an article appears on the earth inductor compass, commencing at page 46 through page 48, inclusive, in said bulletin;

8. That C. W. Burrows was an employee of the Bureau of Standards from some time prior to 1912 to about 1919; that while such employee said Burrows made certain inventions and secured United States letters patent thereon numbered, respectively, as follows:

1322405, November 18, 1919. Method of an apparatus for testing magnetizable objects by magnetic leakage.

1329578, February 3, 1920. Relay.

1459970, June 26, 1923. Method of and apparatus for testing magnetizable objects.

1322405, November 18, 1919. Method of and apparatus for testing magnetizable objects by magnetic leakage.

9. That John A Willoughby was an employee at the Bureau of Standards from some time in 1918 to 1922; that while such employee said Willoughby made a certain alleged invention and secured United States letters patent thereon No. 1555345, dated September 29, 1925; that the said Willoughby is referred to at page 590 of Bureau of Standards Scientific Paper No. 431, entitled "The Field Radiated From Two Horizontal Coils," written by Gregory Breit.

10. That Francis W. Dunmore was an employee of the Bureau of Standards from 1918 and is now so employed; that while such employee said Dunmore made certain inventions and secured United States letters patent thereon numbered as follows:

1577613, dated March 23, 1926, for radio receiving apparatus.

1605333, dated November 2, 1926, for radio receiving apparatus.

That the said Francis W. Dunmore wrote the scientific paper of the Bureau of Standards, No. 536, entitled "A Portable Radio Direction Finder for 90 to 7,700 Kilocycles."

11. That the scientific papers of the Bureau of Standards hereinbefore noted in this stipulation were issued by the said Bureau of Standards as its scientific papers.

EXHIBITS UNDER RULE 46

(Patent No. 984582 received in evidence under rule 46 and marked "Defendant's Exhibit J.")

(Patent No. 1031802 received in evidence under rule 46 and marked "Defendant's Exhibit K.")

(Patent No. 1035373 received in evidence under rule 46 and marked "Defendant's Exhibit L.")

(Patent No. 1038775 received in evidence under rule 46 and marked "Defendant's Exhibit M.")

(Patent No. 1044217 received in evidence under rule 46 and marked "Defendant's Exhibit N.")

(Patent No. 1095506 received in evidence and marked "Defendant's Exhibit O.")

(Patent No. 1156364 received in evidence under rule 46 and marked "Defendant's Exhibit P.")

(Patent No. 1226091 received in evidence under rule 46 and marked "Defendant's Exhibit Q.")

(Patent Re. No. 17242 received in evidence and marked under rule 46 "Defendant's Exhibit R.")

(Patent No. 1724495 received in evidence under rule 46 and marked "Defendant's Exhibit S.")

(Patent No. 1724720 received in evidence and marked under rule 46 "Defendant's Exhibit T.")

(Patent No. 1357197 received in evidence under rule 46 and marked "Defendant's Exhibit U.")

(Scientific Paper No. 217 received in evidence under rule 46 and marked "Defendant's Exhibit V.")

(Scientific Paper No. 290 received in evidence under rule 46 and marked "Defendant's Exhibit W.")

(Patent No. 1418362 received in evidence under rule 46 and marked "Defendant's Exhibit X.")

(Patent No. 1458165 received in evidence under rule 46 and marked "Defendant's Exhibit Y.")

(Patent No. 1450061 received in evidence under rule 46 and marked "Defendant's Exhibit Z.")

(Patent No. 1563557 received in evidence under rule 46 and marked "Defendant's Exhibit AA.")

(Scientific Paper No. 398 received in evidence under rule 46 and marked "Defendant's Exhibit BB.")

(Scientific Paper No. 338 received in evidence under rule 46 and marked "Defendant's Exhibit CC.")

(Patent No. 1649828 received in evidence under rule 46 and marked "Defendant's Exhibit DD.")

(Patent No. 1688713 received in evidence under rule 46 and marked "Defendant's Exhibit EE.")

(Patent No. 1688714 received in evidence under rule 46 and marked "Defendant's Exhibit FF.")

(Patent No. 1648689 received in evidence under rule 46 and marked "Defendant's Exhibit GG.")

(Research Paper No. 40 received in evidence under rule 46 and marked "Defendant's Exhibit HH.")

(Scientific Paper No. 569 received in evidence under rule 46 and marked "Defendant's Exhibit II.")

(Patent No. 1439562 received in evidence and marked under rule 46 "Defendant's Exhibit JJ.")

(Patent No. 1439563 received in evidence under rule 46 and marked "Defendant's Exhibit KK.")

(Scientific Paper No. 449 received in evidence under rule 46 and marked "Defendant's Exhibit LL.")

(Patent No. 1723636 received in evidence under rule 46 and marked "Defendant's Exhibit MM.")

(Technological Paper No. 320 received in evidence under rule 46 and marked "Defendant's Exhibit NN.")

(Patent No. 1660751 received in evidence under rule 46 and marked "Defendant's Exhibit OO.")

(British Patent No. 184773 received in evidence under rule 46 and marked "Defendant's Exhibit PP.")

(German Patent No. 424287 received in evidence under rule 46 and marked "Defendant's Exhibit QQ.")

(Article in Commercial Standards Monthly, page 256, received in evidence and marked under rule 46 "Defendant's Exhibit RR.")

(Article in Proceedings of the American Philosophical Society received in evidence under rule 46 and marked "Defendant's Exhibit SS.")

(Article in Mechanical Engineering, October, 1925, page 795, received in evidence and marked under rule 46 "Defendant's Exhibit TT.")

(Article in Report No. 128, National Advisory Committee for Aeronautics, page 46, received in evidence under rule 46 and marked "Defendant's Exhibit UU.")

(Patent No. 1322405 received in evidence under rule 46 and marked "Defendant's Exhibit VV.")

(Patent No. 1329578 received in evidence under rule 46 and marked "Defendant's Exhibit WW.")

(Patent No. 1340698 received in evidence under rule 46 and marked "Defendant's Exhibit XX.")

(Patent No. 1459970 received in evidence under rule 46 and marked "Defendant's Exhibit YY.")

(Patent No. Reissue 15859 received in evidence under rule 46 and marked "Defendant's Exhibit ZZ.")

(Patent No. 1555345 received in evidence under rule 46 and marked "Defendant's Exhibit AAA.")

(Scientific Paper No. 431 received in evidence under rule 46 and marked "Defendant's Exhibit BBB.")

(Patent No. 1577613 received in evidence under rule 46 and marked "Defendant's Exhibit CCC.")

(Patent No. 1605333 received in evidence under rule 46 and marked "Defendant's Exhibit DDD.")

(Scientific Paper No. 536 received in evidence under rule 46 and marked "Defendant's Exhibit EEE.")

Stipulation as to condensed record

(Filed September 21, 1931)

And now, to-wit, this 21st day of September, A. D. 1931, it is STIPULATED by and between counsel for the respective parties to the hereinbefore entitled causes, subject to the approval of the court, that the foregoing transcript of the record of proceedings at the trial of said causes (said causes having been consolidated for the purpose of trial and tried together) in condensed form, the testimony of witnesses being stated only in narrative form, save that in preparing said record the part of the testimony desired by the respective parties to be reproduced in the exact words of the witnesses has been left in question and answer form, shall be treated and considered as the record of the trial of said causes in making up the transcript of record on appeal.

(Sgd.) LEONARD E. WALES,
United States Attorney,
Solicitor for Plaintiff-Appellant.

(Sgd.) JAMES H. HUGHES, Jr.,
Solicitor for Defendant-Appellee.

ALEXANDER HOLTZOFF,
(Sgd.)
Special Assistant to the Attorney General.

Order approving condensed record

(Filed September 21, 1931)

And now, to-wit, this 21st day of September, A. D. 1931, upon reading and considering the foregoing stipulation, it is, upon motion of Leonard E. Wales, Esq., United States Attorney for the District of Delaware, solicitor for plaintiff.

ORDERED by the court that the foregoing condensed statement of the record of proceedings at the trial of said causes, to be incorporated in the transcript of record on appeal, be and hereby is approved.

(Sgd.) JOHN P. NIELDS,
United States District Judge.

Opinion

(Filed April 27, 1931)

In the District Court of the United States for the District of Delaware

No. 788, in equity, re U. S. Patent No. 1455141

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

No. 789, in equity, re U. S. Patent No. 1606212

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

No. 790, in equity, re U. S. Patent No. 1635117

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Francis W. Dunmore and Percival D. Lowell were employed by the United States in the radio section of the Bureau of Standards. While so employed they conceived the idea of using ordinary house lighting alternating current in the operation of radio apparatus and of means for eliminating hum caused by the alternations of such current; and they made certain inventions embodying the idea.

Upon applications filed in the United States Patent Office, three patents issued: No. 1455141 to Percival D. Lowell and Francis W. Dunmore for "Improvements in Radio Receiving Apparatus"; No. 1606212 to Francis W. Dunmore and Percival D. Lowell for a "Power Amplifier"; and No. 1635117 to Francis W. Dunmore for a "Signal-Receiving System." The patentees granted an exclusive license under each of the three patents to the defendant, Dubilier Condenser Corporation, but excepted from such license a nonexclusive, per-

sonal, nontransferable license to the United States for governmental purposes under each patent. The United States is not content with such licenses and seeks in these three suits (tried together) to obtain a decree compelling the defendant to convey to the United States all defendants' right, title, and interest in the patents.

Title to the patents in suit is the issue in these cases. Their validity has been adjudicated by this court. Dubilier Condenser Corp. *v.* Radio Corp. of America, 34 Fed. (2d) 450. The United States claims title apparently on the theory that the chief of the radio section of the Bureau of Standards assigned to the patentees, Dunmore or Lowell, or to both of them, as research workers in the laboratory of the radio section of the bureau, the problems of devising apparatus for operating a radio-receiving set, a radio loud speaker, and a radio relay by the use of ordinary house-lighting alternating current with the hum eliminated; and that the apparatus covered by the patents in suit was devised by Dunmore or Lowell, or both of them, at the laboratory of the radio section during the usual hours of work and by the use of tools and facilities of the United States, pursuant to the instructions and directions of the chief of that section. In other words, the United States claims that the inventions covered by the three patents in suit, being the product and the result of the work of employees of the United States in solving radio-research problems assigned to them by their superior in the course of their employment, became ipso facto and are the property of their employer, the United States. The defendant, on the other hand, asserts that there was no written or oral agreement on the part of the patentees to convey any patents devised in the course of their employment to their employer; that the character of their employment raised no implication of an agreement to convey patents; that there was no assignment by any superior of Lowell and Dunmore, or of either of them, of a problem, or problems, involving the inventions covered by the patents in suit; and that no duty rested upon the patentees to convey their patents to their employer even though to perfect their inventions they used their employer's property, received the assistance of others in their employer's pay, and took time which should have been given to their employer's business, their employer, the United States, being fully compensated in this regard by a non-exclusive license under the patents.

The Bureau of Standards is a subdivision of the Department of Commerce of the United States. Its functions consist in the custody of standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction of standards, their multiples and subdivisions; the testing and calibration of standard measuring appa-

ratus; the solution of problems which arise in connection with standards; and the determination of physical constants and the properties of materials. In addition the Bureau of Standards during the years hereinafter referred to was charged by Congress with the duty of investigation and standardization of methods and instruments employed in radio communication, for which work Congress made special appropriations. (Act of March 3, 1901, 31 Stat. 1449, U. S. Code, Title 15, secs. 271–281; act of March 4, 1915, 38 Stat. 1044; act of May 29, 1920, 41 Stat. 682, 684; act of March 3, 1921, 41 Stat. 1301, 1303.) In recent years the Bureau of Standards has been engaged in research and testing work of various kinds for the benefit of private industries, other departments of the Government, and the general public.

The Bureau of Standards is divided into divisions, each charged with a specified field of activity. One of such divisions is the electrical division. The various divisions are further subdivided into sections. One of the sections of the electrical division is the radio section. In 1921 and 1922 the employees in the laboratory of the radio section numbered approximately twenty technical men and a number of draftsmen and mechanics. The technical men were engaged in testing radio apparatus and methods and in radio research work. They were subdivided into ten groups, each group having a group chief. In outlines of radio work by the chief of the section or alternate chief the work of each group was defined.

In the years 1921 and 1922 Francis W. Dunmore and Percival D. Lowell were employees of the radio section and were engaged in research and testing in the laboratory of the section. In the outlines of laboratory work the subject of "airplane radio" was assigned to the group of which Dunmore was chief and Lowell a member. The subject of "radio receiving sets" was assigned to a group of which J. L. Preston was chief, but of which neither Lowell nor Dunmore was a member. From January 14, 1918, to the date of filing the bills of complaint in this case, Dunmore was employed in the radio section in the successive capacities of laboratory assistant, assistant physicist, and associate physicist, at annual salaries of $1,320, $1,500, $1,680, $1,980, $2,100, and $2,400. Between February 4, 1913, and July 15, 1922, Lowell was employed in the radio section in the successive capacities of laboratory apprentice, aid, laboratory assistant, and assistant physicist, at annual salaries of $480, $540, $600, $720, $900, $1,000, $1,200, $1,320, $1,500 $1,800, and $1,980.

In May, 1921, the Air Corps of the Army and the Bureau of Standards entered into an arrangement whereby the latter undertook the prosecution of forty-four research projects for the benefit of the Air Corps. To pay the cost of such work, the Air Corps transferred and allocated to the bureau the sum of $267,500. Projects

Nos. 37 to 42, inclusive, relating to the use of radio in connection with aircraft, were assigned to the radio section and $25,000 of the total amount was allocated to pay the cost of the work. Project No. 38 was styled "visual indicator for radio signals," and suggested the construction of a modification of what was known as an "Eckhart recorder." Project No. 42 was styled "airship bomb control and marine torpedo control." Both projects required the design of a radio relay, that is, of a mechanism for use on an airplane to receive the output from a radio receiver and to relay it to a coil on the airplane, which would operate either a visual indicator or a trigger; such trigger to release a bomb on a pilotless plane or a marine torpedo. The relay for the trigger was to operate at the rate of from 10 to 12 times per second upon a current of 500 microamperes.

In the spring of 1921, the Signal Corps of the Army allocated to the bureau between $10,000 and $20,000 for radio research on several specific problems including the design of a suitable relay for use of the Air Corps, already comprised in aircraft projects Nos. 38 and 42.

In the summer of 1921, Dunmore, being chief of the group to whom "airplane radio" problems had been assigned, without further instructions from his superiors, picked out for himself the above-mentioned problem of operating a relay "at the rate of from 10 to 12 times per second upon a current of 500 microamperes" * * * "as one of particular interest and having perhaps a rather easy solution, and worked on it." In September, Dunmore solved this problem by substituting two tubes for two coils in the recording apparatus devised by Dr. Eckhart and called the relay "type A relay." This relay was supplied with power by direct current from a battery aboard ship. The above problem dealt with remote control of bomb on airship and torpedo in the sea.

In the midst of aircraft problems and numerous routine problems of the section Dunmore was wrestling in his own mind, impelled thereto solely by his own scientific curiosity, with the problem of substituting house-lighting alternating current for direct battery current in radio apparatus. He conceived the idea of obtaining a negative bias on the grid of an electron tube from alternating current and tested his idea by substituting a power pack generating alternating current, together with his new apparatus, in a type A relay, in place of the battery. This substitution gave him a relay for operating a telegraph instrument, but was in no way related to the remote-control relay devised for aircraft use. The conception of applying alternating current related particularly to broadcast reception. Dunmore describes the conception in the following words: "After our work on elimination of batteries for broadcast

reception was started, I had available a power-supply unit which (I) connected on to the type A relay, eliminating the use of batteries, with the type A, and later when I put the type A relay and the power unit in the same box, I gave it the name of a type B relay, but it was nothing more than a type A relay with a power pack in the box to operate the type A relay without batteries." The idea of obtaining a negative grid bias for an electron tube from alternating current was conceived by Dunmore on August 3, 1921, and he reduced the invention to practice on December 16, 1921. In the early part of 1922 Dunmore advised his superior of his invention and spent additional time in perfecting the details. Later he constructed two type B relays for the Signal Corps of the Army. Detailed drawings for the finished form of type B relay were prepared during office hours by a draftsman employed at the bureau and the apparatus was constructed from Government material by mechanics employed at the shop of the bureau during office hours. Dunmore's work on type B relay was reflected in his official reports and notebook. He described both types A and B relays in an article, approved by the bureau, and published in the Journal of the American Institute of Electrical Engineers. February 27, 1922, Dunmore filed an application for a patent for a signal-receiving system and on July 5, 1927, patent No. 1635117 was issued.

In 1919 or 1920 the radio section had developed a radio transmitting apparatus supplied with power by alternating current instead of batteries, which was described in a bureau publication. A transmitting apparatus is unlike a receiving apparatus and, in particular, does not involve the question of the elimination of hum produced by the use of alternating current. In the fall of 1921 both Dunmore and Lowell were considering the problem of applying alternating current to broadcast receiving sets. This project was not involved or even suggested by the problems with which the radio section was then dealing and was not assigned by Dr. Dellinger or by any other superior as a task to be solved by either of these employees. It was a project independent of their work and was voluntarily assumed.

While performing their regular tasks Dunmore and Lowell experimented at the laboratory in devising apparatus, including a transformer, rectifier, resistors, and condenser, for the purpose of operating a radio receiving set by alternating current with the hum incident thereto eliminated. The invention of this radio receiving apparatus, covered by patent No. 1455141, was completed by Dunmore and Lowell on December 10, 1921, as appears in Dunmore's notebook, under that date. The claims of the patent can readily be read on the diagram appearing in his notebook under that date. The receiving set was heard in successful operation prior to Christmas, 1921, and during the Christmas holidays. Before the completion of this invention on

December 10, 1921, no instructions were received and no conversations were held by these employees with Dr. Dellinger, the head of the radio section, or with any superior in the bureau relative to the invention. On January 9, 1922, Dr. Dellinger came to the room of Dunmore and Lowell in the laboratory and asked Lowell what he had been doing. In answer, Lowell wrote a memorandum about his work on the high-frequency bridge and the receiving set operated by alternating current. Thereupon Dr. Dellinger requested a detailed report of Mr. Lowell's work on both the high frequency bridge and the receiving set. At no stage does it appear that Dr. Dellinger contributed any suggestions. Thereafter Lowell did engineering work in refining and perfecting the receiving set apparatus, but nothing new was added to the invention of December 10, 1921. Detailed drawings were prepared during office hours by a draftsman employed at the laboratory, following instructions of Lowell and Dunmore and the apparatus was built out of Government material. Lowell described the development of this radio receiving set in a technical paper published by the Bureau of Standards October 2, 1922, entitled "An Electron Tube Amplifier Using 60-Cycle Alternating Current to Supply Power for the Filaments and Plates." March 27, 1922, Lowell and Dunmore filed an application for a patent for radio-receiving apparatus and on May 15, 1923, patent No. 1455141 was issued.

Dunmore and Lowell also conceived the invention of energizing a dynamic type of a loud speaker from an alternating house-lighting circuit and reduced the invention to practice on January 25, 1922. In the technical paper mentioned above Lowell described this invention. March 21, 1922, Dunmore and Lowell filed an application for a "power amplifier," and on November 9, 1926, patent No. 1606212 was issued. The invention embodied in this patent was devised by the patentees without suggestion, instruction, or assignment from any superior.

In June and July, 1922, Dr. Dellinger made demands on Dunmore and Lowell that they assign the applications for the above-recited patents to the United States. These demands were refused. Afterwards a representative of the Attorney General of the United States made a similar demand on Dunmore and Lowell which was refused. Before making the applications for the patents no one advised Dunmore or Lowell that they would be expected to assign exclusive rights in their inventions to the United States.

October 20, 1924, Lowell and Dunmore granted to the defendant, Dubilier Condenser Corporation, an exclusive license under Letters Patent No. 1455141, subject to a nonexclusive license in the United States to use the invention without royalty for the full term of the patent.

May 19, 1927, Dunmore and Lowell granted to defendant an exclusive license under Letters Patent No. 1606212, subject to a nonexclusive license in the United States.

July 15, 1927, Dunmore granted to the defendant an exclusive license under Letters Patent No. 1635117, subject to a nonexclusive license in the United States.

It is well settled that the Government as an employer has no greater right to inventions made by its employees than other employers. It is conceded that there was no express contract between the two employees and the United States that patents covering inventions made by the employees during their employment should belong to the employer. It is difficult to gather from the briefs and argument whether the United States relies on the law of contracts or the law of master and servant, or on both, to support its contentions. Apparently the Government is seeking to enlarge the scope of the duties which an employee owes to his employer respecting patents. The Government claims to find support for its positions in the cases of Solomons *v.* United States, 137 U. S. 342; Standard Parts Co. *v.* Peck, 264 U. S. 52; and Houghton *v.* United States, 23 Fed. (2d) 386, affirming 20 Fed. (2d) 434.

In Solomons *v.* United States, Clark, while Chief of the Bureau of Engraving and Printing, was assigned to the task of devising a self-cancelling revenue stamp. He devised a stamp which the Treasury adopted. Later he obtained a patent, and an infringement suit was brought against the United States. The only question involved in the case was the right of the United States to use the stamp without paying royalty. Title to the patent was in no way involved. The court divided the master and servant situation into two classes: First, whether a license to the master may be inferred from the facts where there is only a general employment; and, second, where there is a specific hiring to devise an improvement, the master's rights in any resulting invention arise as a matter of law. The extent of such rights, beyond a license, was not involved in the case. Mr. Justice Brewer, speaking for the court, said: "An employe, performing all the duties assigned to him in his department of service, may exercise his inventive faculties in any direction he chooses, with the assurance that whatever invention he may thus conceive and perfect is his individual property. There is no difference between the Government and any other employer in this respect. But this general rule is subject to these limitations. If one is employed to devise or perfect an instrument or a means for accomplishing a prescribed result, he can not, after successfully accomplishing the work for which he was employed, plead title thereto as against his employer. That which he has been employed and paid to accomplish becomes, when

accomplished, the property of his employer. Whatever rights as an individual he may have had in and to his inventive powers, and that which they are able to accomplish, he has sold in advance to his employer. So, also, when one is in the employ of another in a certain line of work, and devises an improved method or instrument for doing that work, and uses the property of his employer and the services of other employes to develop and put in practicable form his invention, and explicitly assents to the use by his employer of such invention, a jury, or a court trying the facts, is warranted in finding that he has so far recognized the obligations of service flowing from his employment and the benefits resulting from his use of the property, and the assistance of the coemployes of his employer, as to have given to such employer an irrevocable license to use such invention."

The only application of the above authority to the facts in this case is the recognition of the patentees' title to their own inventions, subject to a nonexclusive license in the Government.

The primary question in the case of Standard Parts *v.* Peck was the legal effect of an express contract. Peck, a designer of machinery and a patent attorney, had expressly agreed to devote his time to the development of machinery for the production of an automobile spring. He proceeded under his contract and developed a machine satisfactory to his employer. Peck patented his invention and sued his employer for infringement. That this case has no bearing on the question under consideration is quite apparent from the statements of Judge Westenhaver (295 Fed. 740), sustaining the right of the employer to the Peck invention. He said: "In this case plaintiff was employed for a specific purpose. He had no general employment, and performed no services, except in that one capacity. The entire consideration received by him was paid in developing the process and machinery which has eventuated in a patentable invention. He was not employed generally in a certain line of work, and devised merely an improved method or instrument for doing that work. He was employed and paid to develop a process or machinery or means of accomplishing a prescribed result. The patentable invention is the result solely of that which he was employed and paid to accomplish. The results thus accomplished, even if of a patentable nature, should accrue wholly to the employer; otherwise, the employer is deprived of a part of that for which he has paid. No invention ever would have been made, except for this contract of employment and expenditure of the employer. The employee, it seems to me, has sold in advance whatever rights as

an individual he may have had in and to his inventive powers, so far as they relate to the work he was to do or the results which he accomplished."

The Supreme Court, in affirming Judge Westenhaver, recognized that the interpretation of an express contract was the vital point of the case, and held that an invention of a specific thing may be made the subject of a bargain, and that such was the object and effect of Peck's contract.

The remaining authority relied upon by the Government is the case of Houghton *v.* United States, in the Circuit Court of Appeals for the Fourth Circuit. That case is quite different from the instant case. Houghton was a trained chemist employed by the Bureau of Chemistry in the Department of Agriculture. The Public Health Service of the Treasury Department had him transferred and assigned to duties in the hygiene laboratory of that service to devise or discover a safe fumigant. Work on the project which resulted in the invention in suit had begun before Houghton was assigned to the Public Health Service. The laboratory had reported results which proved impracticable. Houghton was instructed to study the technical literature relating to the subject. The Surgeon General appointed a board of three under his own control to carry on the investigation. Of this board Houghton was a member. During the progress of the experiments, Houghton continually reported to his superior and received orders from him for further experiments and investigations. The United States brought suit against Houghton alleging that it was the equitable owner of the patent and entitled to an assignment thereof. The court said: "It is clear, we think, upon these facts, that the case presented is not the ordinary case of an invention made by an employee, who, while discharging the duties assigned to him in his department of service, conceives and perfects an invention. In such case the rule is that the invention is the property of the employee. * * * But the case here presented is that of an employee who makes a discovery or invention while employed to conduct experiments for the purpose of making it. Houghton did not conceive the idea of combining an irritant gas with hydrocyanic acid gas, so as to produce a safe fumigant. That was the idea of Dr. Cumming, the Surgeon General, under whom he was working. He did not conceive the idea of using cyanogen chloride gas as the irritant with the deadly gas. That idea had been advanced in a German periodical, and experiments and studies along that line had previously been conducted at the direction of the Health Service. All that he (Houghton) did was to take the idea of the Surgeon General, upon which the Health Service had been experimenting, and conduct experiments

under its direction, for the purpose of determining how best to produce and combine the gases so as to achieve the result which the Surgeon General had in mind. * * * Under such circumstances, we think there can be no doubt that his invention is the property of his employer, the United States."

Counsel for the Government lay much stress upon the following language of Judge Soper in the District Court (20 Fed. (2d) 434), quoted with approval by the Court of Appeals for the Fourth Circuit: "The broad principle is now laid down by the Supreme Court, too clearly to be misunderstood, that, when an employee merely does what he is hired to do, his successes, as well as failures, belong to his employer. Nor can it be said that one who willingly carries out the orders of his employer is not engaged upon that which he is employed to do. An employee, who undertakes upon the direction of his employer to solve a specific problem within the scope of his general employment, is as truly employed and paid for the particular project as if it had been described at the outset in the contract of employment."

No authority is cited in support of this statement and I have been able to find none in the reported cases. But even assuming that such statement is supported by authority, it has no application to this case because, as fully appears in the findings of fact, there was no assignment by Dr. Dellinger, or by any other superior to these two employees of the radio section of any research problem involving the inventions in controversy. The most that can be said is that Lowell and Dunmore were permitted by Dr. Dellinger, after the inventions had been brought to his attention, to pursue their work in the laboratory and perfect the inventions which had theretofore been made by them.

If the bill is to be sustained, resort must be had to the further position taken by the United States that when an employee of the radio section, one of whose duties is to carry on research work, makes an invention within the field of his work, though without assignment from a superior, such an invention ipso facto becomes the property of the employer; or, stated differently, that all patents of research workers in the radio section of the Bureau of Standards belong to the United States. I am confident that no provision in the organic law creating the bureau or in acts of Congress making appropriations to carry on its work, no well-considered authority or sound reason can be found to support such a position.

The basis of the foregoing position, repeatedly emphasized both in argument and brief, seems to be the assumption that the research work of the Bureau of Standards is primarily concerned with invention. But there is nothing in the record to support this idea. While

it is true that § 2 of the act creating the bureau speaks of the "solution of problems which arise in connection with standards" and some of the appropriation acts refer to "investigation and standardization of methods and instruments employed in radio communication," these statutory provisions fall far short of converting the work of the bureau or any section thereof into "inventive" work, as that word is usually understood. Had Congress any such intention it ought to be expressed in the clearest and plainest words and should not be left to uncertain implications from duties and conduct. The bureau was at times engaged in "research work." "Research" has been defined as the "endeavor to discover, to develop, and to verify knowledge," and "careful or critical inquiry or examination in seeking facts or principles." While invention may and usually does presuppose research, research certainly does not usually involve or result in invention. To say that a person engaged in "research" work is necessarily engaged in "inventive work" is putting an unwarranted construction upon the word "research," not justified by common knowledge or experience.

Half the time of Dunmore and Lowell was occupied in testing work. The other half of their time was occupied in research work, normally invoking their skill, knowledge, and experience. By exercising those faculties within the field of work assigned to them these employees fully performed the duties owing to their employer. For an employee to go beyond such skill, invoke his inventive genius, and make a patentable invention is the unusual and abnormal thing not incident to his general employment.

The Bureau of Standards has upon its staff a large number of employees engaged in specific fields of activity and to a certain extent engaged in research work. To hold that every invention made by one of these research workers under the facts disclosed in this case automatically became the property of the United States would, I think, be not only contrary to the law as laid down by the Supreme Court, but have a strong tendency to destroy the morale of the bureau and take away a just incentive on the part of its employees to make inventions, that is, a personal reward for their efforts, bearing always in mind that the Government is entitled to the full use of all such inventions.

In commenting upon the retirement of Dr. Samuel W. Stratton, formerly Director of the Bureau of Standards, President Hoover, then Secretary of Commerce, said: "While the Massachusetts Institute of Technology is to be congratulated on securing Dr. Stratton, one can not overlook the fact that the desperately poor pay which our Government gives to great experts makes it impossible for us to retain men capable of performing the great responsibility which is

placed upon them. The Institute of Technology, an educational institution, finds no difficulty in paying a man of Dr. Stratton's caliber three times the salary the Government is able to pay him.

"Dr. Stratton has repeatedly refused large offers before, but the inability of the scientific men in the Government to properly support themselves and their families under the living conditions in Washington and to make any provision for old age makes it impossible for any responsible department head to secure such men for public service at Government salaries."

Under such conditions should the normal reward of inventors be withheld from research workers in the Bureau of Standards? I think not. To do so would measurably crush the inventive genius, enthusiasm, and spirit of the employees. It would drive unusual men out of the public service and correspondingly lower the efficiency of the bureau. If the rules of law heretofore prevailing are to be extended to bring about this result, resort should be had to the Congress and not to the courts.

The bills of complaint must be dismissed.

(Sgd.) JOHN P. NIELDS, *J.*

APRIL 27, 1931.

Decree

(Filed May 5, 1931)

In the District Court of the United States for the District of Delaware

No. 788 in equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

And now, to-wit, this fifth day of May, A. D. 1931, this cause having come on to be heard upon pleadings and proofs, and having been argued by counsel for the respective parties and maturely considered by the court, it is now, upon motion of James H. Hughes, jr., Esq., solicitor for defendant,

Ordered, adjudged, and decreed by the court that the bill of complaint in this cause be and hereby is dismissed.

(Sgd.) JOHN P. NIELDS, *J.*

Approved as to form.

(Sgd.) LEONARD E. WALES,
U. S. District Attorney,
District of Delaware.

(Sgd.) CHARLES B. RUGG.

(Sgd.) ALEXANDER HOLTZOFF.

Decree

(Filed May 5, 1931)

In the District Court of the United States for the District of Delaware

No. 789 in equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

And now, to-wit, this fifth day of May, A. D. 1931, this cause having come on to be heard upon pleadings and proofs, and having been argued by counsel for the respective parties and maturely considered by the court, it is now, upon motion of James H. Hughes, jr., Esq., solicitor for defendant,

Ordered, adjudged, and decreed by the court that the bill of complaint in this cause be and hereby is dismissed.

(Sgd.) JOHN P. NIELDS, *J.*

Approved as to form.

(Sgd.) LEONARD E. WALES,
U. S. District Attorney,
District of Delaware.

(Sgd.) CHARLES B. RUGG.

(Sgd.) ALEXANDER HOLTZOFF.

Decree

(Filed May 5, 1931)

In the District Court of the United States for the District of Delaware

No. 790 in equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

And now, to-wit, this fifth day of May, A. D. 1931, this cause having come on to be heard upon pleadings and proofs, and having been argued by counsel for the respective parties and maturely considered by the court, it is now, upon motion of James H. Hughes, jr., Esq., solicitor for defendant,

Ordered, adjudged, and decreed by the court that the bill of complaint in this cause be and hereby is dismissed.

(Sgd.) JOHN P. NIELDS, *J.*

Approved as to form.

(Sgd.) LEONARD E. WALES,
U. S. District Attorney,
District of Delaware.

(Sgd.) CHARLES B. RUGG.

(Sgd.) ALEXANDER HOLTZOFF.

Plaintiff's petition for appeal and order allowing appeal

(Filed June 15, 1931)

In the District Court of the United States for the District of Delaware

In equity No. 788

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

The United States of America, the plaintiff herein, conceiving itself aggrieved by the decree made and entered on the fifth day of May, 1931, in the above-entitled cause, does hereby appeal from the said decree to the United States Circuit Court of Appeals for the Third Circuit, for the reasons specified in the assignment of errors which is filed herewith, and prays that this appeal may be allowed; that citation issue as provided by law; and that a transcript of the record, proceedings, and papers upon which said decree was made, duly authenticated, may be sent to the United States Circuit Court of Appeals for the Third Circuit.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

(Sgd.) ALEXANDER HOLTZOFF,
Special Assistant to the Attorney General.

(Sgd.) FRANK J. KEATING, *Attorney.*

And now, to-wit, on the 15th day of June, 1931, it is ordered that the foregoing appeal be allowed as prayed for.

(Sgd.) JOHN P. NIELDS,
United States District Judge for the District of Delaware.

Plaintiff's petition for appeal and order allowing appeal

(Filed June 15, 1931)

In the District Court of the United States for the District of Delaware

In equity No. 789

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

The United States of America, the plaintiff herein, conceiving itself aggrieved by the decree made and entered on the fifth day of May, 1931, in the above-entitled cause, does hereby appeal from the said decree to the United States Circuit Court of Appeals for the Third Circuit, for the reasons specified in the assignment of errors which is filed herewith, and prays that this appeal may be allowed; that citation issue as provided by law; and that a transcript of the record, proceedings and papers upon which said decree was made, duly authenticated, may be sent to the United States Circuit Court of Appeals for the Third Circuit.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

(Sgd.) ALEXANDER HOLTZOFF,
Special Assistant to the Attorney General.

(Sgd.) FRANK J. KEATING, *Attorney.*

And now, to-wit, on the 15th day of June, 1931, it is ordered that the foregoing appeal be allowed as prayed for.

(Sgd.) JOHN P. NIELDS,
United States District Judge
for the District of Delaware.

Plaintiff's petition for appeal and order allowing appeal

(Filed June 15, 1931)

In the District Court of the United States for the District of Delaware

In equity No. 790

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

The United States of America, the plaintiff herein, conceiving itself aggrieved by the decree made and entered on the fifth day of May, 1931, in the above-entitled cause, does hereby appeal from the said decree to the United States Circuit Court of Appeals for the Third Circuit, for the reasons specified in the assignment of errors which is filed herewith, and prays that this appeal may be allowed; that citation issue as provided by law; and that a transcript of the record, proceedings, and papers upon which said decree was made, duly authenticated, may be sent to the United States Circuit Court of Appeals for the Third Circuit.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

(Sgd.) ALEXANDER HOLTZOFF,
Special Assistant to the Attorney General.

(Sgd.) FRANK J. KEATING,
Attorney.

And now, to wit, on the 15th day of June, 1931, it is ordered that the foregoing appeal be allowed as prayed for.

(Sgd.) JOHN P. NIELDS,
United States District Judge for the District of Delaware.

Plaintiff's assignment of errors

(Filed June 15, 1931)

In the District Court of the United States for the District of Delaware

In equity No. 788

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Now comes the United States of America, the plaintiff herein, by Leonard E. Wales, United States attorney for the District of Delaware, and says that in the decree made and entered herein on the fifth day of May, 1931, there is manifest error, and for error the United States of America assigns the following:

1. The District Court erred in dismissing the bill of complaint herein.

2. The District Court erred in refusing to grant the relief prayed for in the bill of complaint herein.

3. The District Court erred in refusing to hold that the United States of America is the true owner of Letters Patent No. 1455141, issued on May 15, 1923, to Percival D. Lowell and Francis W. Dunmore, and entitled, "Improvements in Radio Receiving Apparatus"; and that the defendant, the Dubilier Condenser Corporation, holds its interest in said patent in trust for the United States of America, and should be directed and compelled to assign, transfer, and convey to the plaintiff all its right, title, and interest in and to the aforesaid invention and the aforesaid letters patent.

4. The District Court erred in making the following finding:

The subject of "radio-receiving sets" was assigned to a group of which J. L. Preston was chief, but of which neither Lowell nor Dunmore was a member.

5. The District Court erred in making the following finding:

In the midst of aircraft problems and numerous routine problems of the section, Dunmore was wrestling in his own mind, impelled thereto solely by his own scientific curiosity, with the problem of substituting house-lighting alternating current for direct battery current in radio apparatus.

6. The District Court erred in making the following finding:

This substitution gave him a relay for operating a telegraph instrument, but was in no way related to the remote control relay devised for aircraft use.

7. The District Court erred in making the following finding:

The idea of obtaining a negative grid bias for an electron tube from alternating current was conceived by Dunmore on August 3, 1921, and he reduced the invention to practice on December 16, 1921. In the early part of 1922, Dunmore advised his superior of his invention and spent additional time in perfecting the details.

8. The District Court erred in making the following finding:

In the fall of 1921 both Dunmore and Lowell were considering the problem of applying alternating current to broadcast receiving sets. This project was not involved or even suggested by the problems with which the radio section was then dealing and was not assigned by Dr. Dellinger or by any other superior as a task to be solved by either of these employees. It was a project independent of their work and was voluntarily assumed.

9. The District Court erred in making the following finding:

The invention of this radio receiving apparatus, covered by patent No. 1455141, was completed by Dunmore and Lowell on December 10, 1921, as appears in Dunmore's notebook, under that date. The claims of the patent can readily be read on the diagram appearing in his notebook under that date. The receiving set was heard in successful operation prior to Christmas, 1921, and during the Christmas holidays.

10. The District Court erred in making the following finding:

Before the completion of this invention on December 10, 1921, no instructions were received and no conversations were held by these employees with Dr. Dellinger, the head of the radio section, or with any superior in the bureau relative to the invention.

11. The District Court erred in making the following finding:

At no stage does it appear that Dr. Dellinger contributed any suggestions.

12. The District Court erred in making the following finding:

Thereafter Lowell did engineering work in refining and perfecting the receiving-set apparatus, but nothing new was added to the invention of December 10, 1921.

13. The District Court erred in making the following finding:

The invention embodied in this patent was devised by the patentees without suggestion, instruction, or assignment from any superior.

Wherefore, the plaintiff prays that the said decree be reversed and that the United States of America be granted the relief prayed for

in the bill of complaint herein and all other and further relief appropriate in the premises.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.)
ALEXANDER HOLTZOFF,
Special Assistant to the Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

(Sgd.)
FRANK J. KEATING,
Attorney.

Plaintiff's assignment of errors

(Filed June 15, 1931)

In the District Court of the United States for the District of Delaware

In equity No. 789

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Now comes the United States of America, the plaintiff herein, by Leonard E. Wales, United States attorney for the District of Delaware, and says that in the decree made and entered herein on the fifth day of May, 1931, there is manifest error, and for error the United States of America assigns the following:

1. The District Court erred in dismissing the bill of complaint herein.

2. The District Court erred in refusing to grant the relief prayed for in the bill of complaint herein.

3. The District Court erred in refusing to hold that the United States of America is the true owner of Letters Patent No. 1606212, issued on November 9, 1926, to Francis W. Dunmore and Percival D. Lowell and entitled "Power Amplifier"; and that the defendant, the Dubilier Condenser Corporation, holds its interest in said patent in trust for the United States of America and should be directed and compelled to assign, transfer, and convey to the plaintiff all its right, title, and interest in and to the aforesaid invention and the aforesaid letters patent.

4. The District Court erred in making the following finding:

The subject of "radio receiving sets" was assigned to a group of which J. L. Preston was chief, but of which neither Lowell nor Dunmore was a member.

5. The District Court erred in making the following finding:

In the midst of aircraft problems and numerous routine problems of the section, Dunmore was wrestling in his own mind, impelled thereto solely by his own scientific curiosity, with the problem of substituting house-lighting alternating current for direct battery current in radio apparatus.

6. The District Court erred in making the following finding:

This substitution gave him a relay for operating a telegraph instrument, but was in no way related to the remote-control relay devised for aircraft use.

7. The District Court erred in making the following finding:

The idea of obtaining a negative grid bias for an electron tube from alternating current was conceived by Dunmore on August 3, 1921, and he reduced the invention to practice on December 16, 1921. In the early part of 1922 Dunmore advised his superior of his invention and spent additional time in perfecting the details.

8. The District Court erred in making the following finding:

In the fall of 1921 both Dunmore and Lowell were considering the problem of applying alternating current to broadcast receiving sets. This project was not involved or even suggested by the problems with which the radio section was then dealing and was not assigned by Dr. Dellinger or by any other superior as a task to be solved by either of these employees. It was a project independent of their work and was voluntarily assumed.

9. The District Court erred in making the following finding:

At no stage does it appear that Dr. Dellinger contributed any suggestions.

10. The District Court erred in making the following finding:

Thereafter Lowell did engineering work in refining and perfecting the receiving set apparatus, but nothing new was added to the invention of December 10, 1921.

11. The District Court erred in making the following finding:

The invention embodied in this patent was devised by the patentees without suggestion, instruction or assignment from any superior.

WHEREFORE, the plaintiff prays that the said decree be reversed and that the United States of America be granted the relief prayed for in the bill of complaint herein and all other and further relief appropriate in the premises.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

ALEXANDER HOLTZOFF,
(Sgd.)
Special Assistant to the Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

FRANK J. KEATING,
(Sgd.)
Attorney.

Plaintiff's assignment of errors

(Filed June 15, 1931)

In the District Court of the United States for the District of Delaware

In equity, No. 790

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

Now comes the United States of America, the plaintiff herein, by Leonard E. Wales, United States attorney for the District of Delaware, and says that in the decree made and entered herein on the fifth day of May, 1931, there is manifest error, and for error the United States of America assigns the following:

1. The District Court erred in dismissing the bill of complaint herein.

2. The District Court erred in refusing to grant the relief prayed for in the bill of complaint herein.

3. The District Court erred in refusing to hold that the United States of America is the true owner of Letters Patent No. 1635117, issued on July 5, 1927, to Francis W. Dunmore, and entitled "Signal-receiving System"; and that the defendant, the Dubilier Condenser Corporation, holds its interest in said patent in trust for the United States of America, and should be directed and compelled to assign, transfer, and convey to the plaintiff all its right, title, and interest in and to the aforesaid invention and the aforesaid letters patent.

4. The District Court erred in making the following finding:

The subject of "radio-receiving sets" was assigned to a group, of which J. L. Preston was chief, but of which neither Lowell nor Dunmore was a member.

5. The District Court erred in making the following finding:

In the midst of aircraft problems and numerous routine problems of the section, Dunmore was wrestling in his own mind, impelled thereto solely by his own scientific curiosity, with the problem of substituting house-lighting alternating current for direct battery current in radio apparatus.

6. The District Court erred in making the following finding:

This substitution gave him a relay for operating a telegraph instrument, but was in no way related to the remote-control relay devised for aircraft use.

7. The District Court erred in making the following finding:

The idea of obtaining a negative grid bias for an electron tube from alternating current was conceived by Dunmore on August 3, 1921, and he reduced the invention to practice on December 16, 1921. In the early part of 1922, Dunmore advised his superior of his invention and spent additional time in perfecting the details.

8. The District Court erred in making the following finding:

At no stage does it appear that Dr. Dellinger contributed any suggestions.

9. The District Court erred in making the following finding:

The invention embodied in this patent was devised by the patentees without suggestion, instruction, or assignment from any superior.

Wherefore, the plaintiff prays that the said decree be reversed and that the United States of America be granted the relief prayed for in the bill of complaint herein and all other and further relief appropriate in the premises.

(Sgd.) CHARLES B. RUGG,
Assistant Attorney General.

(Sgd.) LEONARD E. WALES,
United States Attorney for the District of Delaware.

ALEXANDER HOLTZOFF,
(Sgd.)
Special Assistant to the Attorney General.

FRANK J. KEATING,
(Sgd.)
Attorney.

Citation

(Filed June 16, 1931)

In the District Court of the United States for the District of Delaware

No. 788 in equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

UNITED STATES OF AMERICA, ss:

The President of the United States.

To Dubilier Condenser Corporation, a corporation organized and existing under the laws of the State of Delaware,

Greeting: You are hereby cited and admonished to be and appear in the United States Circuit Court of Appeals for the Third Circuit, to be holden at the courtroom thereof, in the city of Philadelphia, State of Pennsylvania, on the fifteenth day of July, A. D. 1931, pursuant to an appeal duly obtained from a decree of the District Court of the United States for the District of Delaware, entered on the fifth day of May, A. D. 1931, in the cause therein pending wherein United States of America is plaintiff-appellant and you are defendant-appellee, to show cause, if any there be, why the decree against the appellant in said appeal mentioned should not be corrected, and why speedy justice should not be done to the parties in that behalf.

Given under my hand in the city of Wilmington, in the district of Delaware, this fifteenth day of June, A. D. 1931, and the independence of the United States of America the one hundred and fifty-fifth.

(Sgd.) JOHN P. NIELDS,

United States District Judge, District of Delaware.

Service of the foregoing citation, with copy, and with copy of petition for appeal, order allowing appeal, and assignment of errors accepted this 16th day of June, A. D. 1931.

(Sgd.) E. ENNALLS BERL,

Solicitor for Defendant-Appellee.

Citation

(Filed June 16, 1931)

In the District Court of the United States for the District of Delaware

No. 789 in equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

UNITED STATES OF AMERICA, ss:

The President of the United States.

To Dubilier Condenser Corporation, a corporation organized and existing under the laws of the State of Delaware,

Greeting: You are hereby cited and admonished to be and appear in the United States Circuit Court of Appeals for the Third Circuit, to be holden at the courtroom thereof, in the city of Philadelphia, State of Pennsylvania, on the fifteenth day of July, A. D. 1931, pursuant to an appeal duly obtained from a decree of the District Court of the United States for the District of Delaware, entered on the fifth day of May, A. D. 1931, in the cause therein pending wherein United States of America is plaintiff-appellant and you are defendant-appellee, to show cause, if any there be, why the decree against the appellant in said appeal mentioned should not be corrected, and why speedy justice should not be done to the parties in that behalf.

Given under my hand in the city of Wilmington, in the District of Delaware, this fifteenth day of June, A. D. 1931, and the independence of the United States of America the one hundred and fifty-fifth.

(Sgd.) JOHN P. NIELDS,
United States District Judge, District of Delaware.

Service of the foregoing citation, with copy, and with copy of petition for appeal, order allowing appeal and assignment of errors, accepted this 16th day of June, A. D. 1931.

(Sgd.) E. ENNALLS BERL,
Solicitor for defendant-appellee.

Citation

(Filed June 16, 1931)

In the District Court of the United States for the District of Delaware

No. 790 in equity

UNITED STATES OF AMERICA, PLAINTIFF

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT

UNITED STATES OF AMERICA, ss:

The President of the United States,

To Dubilier Condenser Corporation, a corporation organized and existing under the laws of the State of Delaware.

Greeting: You are hereby cited and admonished to be and appear in the United States Circuit Court of Appeals for the Third Circuit, to be holden at the courtroom thereof, in the city of Philadelphia, State of Pennsylvania, on the fifteenth day of July, A. D. 1931, pursuant to an appeal duly obtained from a decree of the District Court of the United States for the District of Delaware, entered on the fifth day of May, A. D. 1931, in the cause therein pending wherein United States of America is plaintiff-appellant and you are defendant-appellee, to show cause, if any there be, why the decree against the appellant in said appeal mentioned should not be corrected, and why speedy justice should not be done to the parties in that behalf.

Given under my hand in the city of Wilmington, in the District of Delaware, this fifteenth day of June, A. D. 1931, and the independence of the United States of America the one hundred and fifty-fifth.

(Sgd.) JOHN P. NIELDS,
United States District Judge, District of Delaware.

Service of the foregoing citation, with copy, and with copy of petition for appeal, order allowing appeal and assignment of errors, accepted this 16th day of June, A. D. 1931.

(Sgd.) E. ENNALLS BERL,
Solicitor for Defendant-Appellee.

Stipulation as to transcript of record

(Filed September 21, 1931)

In the District Court of the United States for the District of Delaware

No. 788 in equity, re U. S. Patent No. 1455141

UNITED STATES OF AMERICA, PLAINTIFF

vs.

DUBILIER CONDENSER CORPORATION, DEFENDANT

No. 789 in equity, re U. S. Patent No. 1606212

UNITED STATES OF AMERICA, PLAINTIFF

vs.

DUBILIER CONDENSER CORPORATION, DEFENDANT

No. 790 in equity, re U. S. Patent No. 1635117

UNITED STATES OF AMERICA, PLAINTIFF

vs.

DUBILIER CONDENSER CORPORATION, DEFENDANT

It is hereby stipulated and agreed by and between counsel for the respective parties to the above-entitled causes with respect to the transcript of record on the appeals taken by the plaintiff from the decrees entered in the said causes on the fifth day of May, 1931, that the three causes having been consolidated for the purpose of trial and tried together, a single consolidated transcript of record on such appeals may be used in the United States Circuit Court of Appeals for the Third Circuit for the three causes, and that such consolidated transcript shall consist of the following:

1. Docket entries in each cause.
2. Bill of complaint in each cause.
3. Answer in each cause.
4. Record of proceedings at trial in condensed form, as approved by the court.
5. Opinion of the court.
6. Final decree in each cause.

7. Petition of plaintiff for appeal, with assignments of error and order allowing appeal in each cause.

8. Citation in each cause.

9. Plaintiff's Exhibits Nos. 1 to 3 and 7 to 66 A.

10. Defendant's Exhibits Nos. 2 to 8; 10 to 12; the first page and a summary of Exhibit 1; the first page and a summary of Exhibit 9; and the title page and pages 17, 18, 19, and 20, 272, 273, of Exhibit 13, and title page and pages 1, 2, and 3, 281 and 282 of Exhibit 14.

11. This stipulation and order approving same.

12. Clerk's certificate.

It is further stipulated and agreed that the plaintiff's Exhibits Nos. 4, 5, 6, 67, 67–A, and 68, and defendant's Exhibits Nos. 1, 9, 13, and 14, except as specified above, and defendant's Exhibits A to EEE, both inclusive, introduced under equity rule 46, may be treated as physical exhibits and not reproduced as a part of the transcript of record on appeal, and may be by the clerk removed from the records and files of this court, and transmitted to the clerk of the United States Circuit Court of Appeals for the Third Circuit, for filing with the transcript of record in said causes.

(Sgd.) LEONARD E. WALES,
United States Attorney,
Solicitor for Plaintiff-Appellant.

(Sgd.) JAMES H. HUGHES, Jr.,
Solicitor for Defendant-Appellee.

ALEXANDER HOLTZOFF,
(Sgd.)
Special Assistant to the Attorney General.
SEPTEMBER 21, 1931.

Order approving stipulation as to transcript of record

(Filed September 21, 1931)

And now, to-wit, this 21st day of September, A. D. 1931, upon motion of Leonard E. Wales, Esq., United States attorney for the District of Delaware, solicitor for plaintiff-appellant, it is

ORDERED by the court that the foregoing stipulation be and the same hereby is approved and the Clerk is hereby authorized to certify the transcript of record prepared in accordance with the foregoing stipulation, and to transmit the same, together with the physical exhibits referred to therein, to the United States Circuit Court of Appeals for the Third Circuit, at Philadelphia, Pennsylvania.

(Sgd.) JOHN P. NIELDS,
United States District Judge.

Clerk's certificate

UNITED STATES OF AMERICA,
District of Delaware, ss:

I, HENRY C. MAHAFFY, Jr., clerk of the District Court of the United States for the District of Delaware, do hereby certify that I have carefully compared the writings annexed to and accompanying this certificate, in two volumes, viz:

Volume I, Pleadings and Testimony, pages 1 to 248, inclusive;

Volume II, Exhibits, pages 1 to 460, inclusive;

and find the same to be true and correct copies of their respective originals so full and complete as the same now remain on file and of record in my office, being a complete exemplification of the record and proceedings in the three cases of United States of America, plaintiff, v. Dubilier Condenser Corporation, defendant, Nos. 788, 789 and 790 in Equity, pending in said court, made up in accordance with the stipulated præcipe of counsel for the respective parties filed in said cause.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the seal of said court, at Wilmington, in said district, this twenty-eighth day of September, A. D. 1931, and the independence of the United States of America the one hundred and fifty-sixth.

(Signed) H. C. MAHAFFY, Jr.,
Clerk, United States District Court,
District of Delaware.

75248—31——17

U. S. GOVERNMENT PRINTING OFFICE: 1931

PLAINTIFF'S EXHIBIT NO. 1

July 5, 1927. 1,635,117

F. W. DUNMORE

SIGNAL RECEIVING SYSTEM

Filed Feb. 27, 1922 3 Sheets-Sheet 1

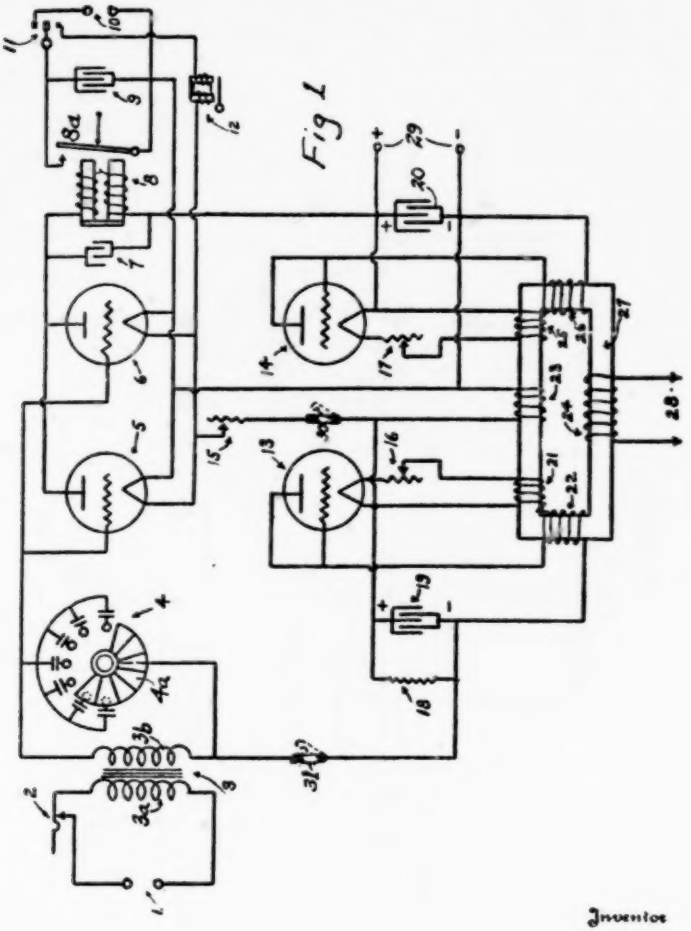

Fig 1

Inventor

Francis W. Dunmore

By John B. Brady.

Attorney

1

PLAINTIFF'S EXHIBIT No. 1—Continued

July 5, 1927. 1,635,117

F. W. DUNMORE

SIGNAL RECEIVING SYSTEM

Filed Feb. 27. 1922 3 Sheets-Sheet 2

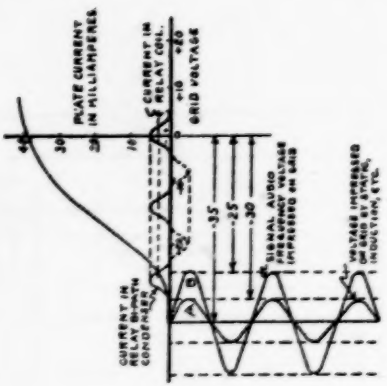

Fig 3

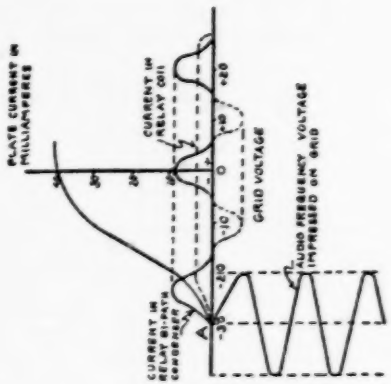

Fig 2.

Inventor

Francis W. Dunmore.

Atty John B. Brady

Attorney

PLAINTIFF'S EXHIBIT No. 1—Continued

Patent No. 1,635,117

July 5, 1927. 1,635,117

F. W. DUNMORE

SIGNAL RECEIVING SYSTEM

Filed Feb. 27. 1922 3 Sheets-Sheet 3

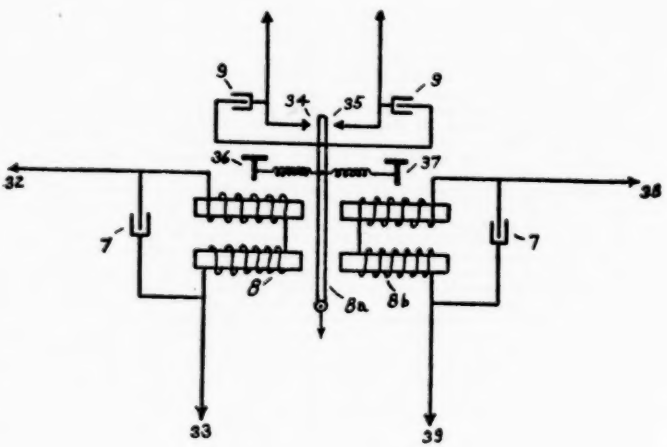

Fig. 4.

Inventor

Francis W. Dunmore.

By John B Brady

Attorney

PLAINTIFF'S EXHIBIT No. 1—Continued

Patented July 5, 1927. 1,635,117

UNITED STATES PATENT OFFICE.

FRANCIS W. DUNMORE, OF WASHINGTON, DISTRICT OF COLUMBIA.

SIGNAL-RECEIVING SYSTEM.

Application filed February 27, 1922. Serial No. 539,891.

My invention relates broadly to audio frequency signal receiving systems and more particularly to relays for operation at a receiving station for the local or remote control of auxiliary apparatus.

My invention has for its principal object the provision of relays selectively operative upon the reception of signals of slightly separated tone frequency and particularly adaptable for reception of signals in wire wireless and radio telegraph systems.

The object of my invention is to provide a circuit arrangement for audio frequency signal receiving relays.

A further object of the invention is to provide a relay which may be constructed as a portable unit and operated from any alternating current source of power circuit supply, such as the residence lighting circuit usually employing an alternating current of 60 cycles frequency at 110 volts, for the positive closing of a circuit at a signal receiving station for the control of any desired local or remote apparatus.

A further object of the invention is to provide a relay with thermionic vacuum tubes with input and output circuit characteristics whereby positive closing of a mechanical relay may be secured in the output circuit of the apparatus upon control of the input circuit from a relatively feeble audio frequency impulse.

A still further object of the invention is to provide a thermionic vacuum tube relay apparatus highly selective in its operation dependent upon the tone frequency of the incoming signals.

Another object of the invention is to provide a complete relay including thermionic vacuum tube circuits with power connections for adaptation to any suitable external source of power, such as primary or secondary batteries or suitable lighting power circuits, with means for adjusting the input and output circuits of the thermionic vacuum tube circuits for the positive reception of signals of different audio tone characteristics.

Another object of the invention is to provide a relay circuit with minimum responsiveness to static and local disturbances not desired to be received.

In constructing the relay of the present invention, for operation in radio telegraph receiving systems, or any other system involving a tone frequency reception, the following characteristics have been secured as necessary requirements for a satisfactory relay to be employed in radio or wire reception as a positive circuit closer for operation of any variety of apparatus at a receiver, such as dynamic control circuits, automatic printing equipment, tape recorders or other recorder circuits for audible reception: (1) The relay must be of simple construction with few adjustments; (2) it must be easy to adjust and capable of being put into operation quickly; (3) it must be selective and as free from static and such disturbances as possible; (4) it must be capable of operating at a speed of at least 50 words a minute; (5) it must respond to weak signals; (6) it must be of rugged design, durable and capable of maintaining its adjustments; and (7) it must be portable.

My invention will be more clearly understood by reference to the following specification and the accompanying drawings, in which: Fig. 1 is a schematic wiring diagram of the relay showing the input circuit and terminals for connection of the relay to an external power supply and audio frequency signal source; Fig. 2 shows the characteristic curves for the thermionic vacuum tubes employed in the relay; Fig. 3 shows the characteristic curves illustrating a method of eliminating static, induction, etc, when such interference is not stronger than the signal; and Fig. 4 is a schematic diagram of an application of the relay.

It will be understood that the principles of my invention may be embodied in various forms and that details are not material. The present embodiment of the invention, therefore, is to be considered as merely indicative. The form illustrated in the drawing and hereinafter described in detail has been found to be one of the practical embodiments and capable of efficient operation and practical in construction for use at a radio and wire receiver for operation of signal recorders. The relay is also applicable to many other uses such as multiplex line wire telegraphy, radiodynamic control and wire wireless operation.

The multiplex operation of the relay with wire wireless is made possible by the audio tuning features of this relay, as the combination of numerous radio frequencies with the various different heterodyne notes thus obtainable provides a wide range for the selective application of the relay for wire

PLAINTIFF'S EXHIBIT No. 1—Continued

wireless Morse telegraphy. Numerous telephone or telegraph lines may be fed from one source of radio frequency, each line having a power amplifier modulated at one or more audio frequencies each of said frequencies selectively operating the present type relay.

The relay comprises broadly an input circuit which is energized from any source of audio frequency current, such as secured after the process of rectification at a wire or radio receiver, or as is secured in multiplex carrier wave telegraphy, or that produced by the heterodyne of two radio frequencies. The input circuit of the relay comprises an audio frequency input transformer the secondary terminals of which are connected to the grids and filaments of one or more receiving tubes which are operated in parallel. This input transformer secondary circuit is made adjustable for desired signals of different tone characteristics by means of a variable condenser shunted across the terminals thereof. The plates of the receiving tube are parallel connected and are included in an external output circuit energized from rectified energy taken from a winding upon an alternating current transformer having its primary winding energized from a source of supply such as the 110 volt 60 cycle residence lighting circuit or from any source of DC supply of from 100 to 200 volts. The current for operating the tube filaments is also obtained from a proportionate winding upon the core of this transformer or from a DC source of supply of suitable voltage. The grid circuit voltage for the bias upon the grids of the vacuum tubes is obtained by rectification of energy supplied from another proportionate winding upon the core of this transformer or from a suitable source of DC voltage.

The rectifiers employed may be two electron tubes having the filaments thereof heated from current derived from proportionate windings upon the core of this transformer. In the output circuit of the amplifier tubes a mechanical relay is arranged, having its winding proportioned with the characteristics of the output circuit and shunted by an audio frequency bi-path condenser. This mechanical relay operates to close a positive electrical circuit which may be employed for the local or remote control of any variety of instruments.

Referring more particularly to Fig. 1 of the drawings, reference character 1 indicates the input terminals for the relay. 2 represents a telephone socket in which may be inserted a pair of telephones by which the operator may check up the operation of the relay or listen to the received signals in the usual way without employing the relay recorder. 3 indicates an audio frequency transformer, the primary winding 3^a of which forms a part of the input circuit of the relay and the secondary winding 3^b of which connects to the input circuit of the tubes 5 and 6. Bridged across the secondary winding 3^b is an audio frequency tuning condenser 4 variable by steps upon the adjustment of switch 4^a. This condenser may also be of the continuously variable air condenser type. The grids of the tubes 5 and 6 are biased from energy derived from proportionate windings upon transformer 27, the primary winding 24 of which connects through terminals 28 with a source of alternating current supply, such as the 110 bolt 60 cycle AC residence lighting current. The transformer 27 contains six windings, including the primary energizing winding 24. A proportionate secondary winding 23 supplies current to the filaments of the power tubes 5 and 6 through rheostat 15. The winding 26 supplies the high voltage for the plate circuit of the tubes 5 and 6. The winding 22 supplies the grid voltage for the tubes 5 and 6.

Tubes 13 and 14 are employed as two electrode valves and are used as half wave rectifiers, tube 14 supplying the plate voltage with energy derived from winding 26, and tube 13 supplying the grid voltage with energy derived from winding 22. In these tubes 13 and 14 the grids and plates are represented as electrically connected, forming two electrode valves. The rectified alternating current is smoothed out for the grid voltage by condenser 19. The rectified alternating current for the plate circuit is smoothed out by condenser 20. These condensers are connected respectively across the output terminals of the rectifiers. The filaments of tubes 13 and 14 are heated from energy derived from proportionate windings 21 and 25, and the temperature controlled by rheostats 16 and 17 respectively. A high resistance leak 18 of a value from 40,000 to 100,000 ohms is shunted across the output circuit of the rectifier tube 13 supplying voltage to the grids of tubes 5 and 6, as otherwise the grids of tubes 5 and 6 are insulated from the filaments of the tubes by the rectifier tube 13. By means of the filament rheostats 16 and 17 the grid and plate voltages respectively may be varied over any ranges desirable for the most efficient operation of the recorder.

Binding posts 29, 30 and 31 are provided on the relay for connection to primary or secondary batteries where the alternating current supply is not available. Binding posts 30 are normally shunted as indicated, but this shunt may be disconnected and connections made with an "A" battery of suitable voltage for filament lighting. Binding posts 31 are normally shunted when power is derived from the AC supply but in the absence of such supply are disconnected and

PLAINTIFF'S EXHIBIT No. 1—Continued

connections made with a "C" battery for biasing the grids of tubes 5 and 6. This battery should be preferably variable from 20 to 80 volts in steps of 10 volts. Binding posts 29 are provided for the connection of a high voltage "B" battery of from 160 to 250 volts for the plate circuit supply in the absence of the alternating current power source.

In the plate circuit of the tubes 5 and 6 the mechanical relay 8 is included. The windings of the relay are proportioned to the internal resistance of tubes 5 and 6 to secure high sensitivity.

A suitable condenser 7 is shunted across the relay winding 8 as a bi-path for the audio frequency plate currents which in turn cause DC plate current fluctuations at the keying frequency, which variations pass through the winding 8 and operate the relay armature 8a. The relay is provided with armature 8a with the circuit closer contact shunted by condenser 9 for absorption of the make and break discharge. The relay may be of the mechanically tuned type in which case condenser 7 would be omitted. The speed of operation is also dependent upon the type of mechanical relay employed.

The circuit closer 8a is arranged in the circuit with switch 11 adapted to be thrown to different contact points to connect the circuit direct to output terminals 10, which may in turn be connected to any local or remote apparatus to be operated by the relay or to connect a test buzzer 12, in circuit with a source of energy from winding 23, which also supplies the filament lighting current for tubes 5 and 6. The buzzer 12 may be of the synchronous type without the vibrator intermittent contact. Any variety of instruments may be connected to the terminals 10, such as a tape or drum type recorder, a printer recorder or dynamic control apparatus.

The principle of operation of the relay will be understood by reference to Fig. 2, which shows a set of curves characteristic of the relay for remote control by radio. By means of the variable biasing potential of the grids of the tubes 5 and 6, obtained by variation of rheostat 16 of rectifier 13, the grid voltage is adjusted to approximately 30 volts, at which value the plate current is zero as indicated at A, Fig. 2.

The incoming audio frequency voltage impressed on the grid varies the grid potential, for example, from —30 to —20 volts, the 10 volts decrease from —30 to —20 causes an increase, for example from 0 to 10 milliamperes in plate current while the increase from —30 to —40 volts is not effective in causing a plate current to flow due to the fact that —30 volts is already sufficient to reduce the plate current to zero. The result will be a pulsating direct current of 10 milliamperes, maximum amplitude in the plate circuit. This current flowing through the plate circuit and condenser 7 causes an increase in the plate current at the keying frequency, which change, passing through the relay coil will pull the relay armature over, making contact at 8a which contact may control any mechanism desired. With the "C" battery grid voltage adjusted for maximum sensitivity, it was found that static, induction, etc., operated the relay. When these disturbances are not as strong as the signal, their effect on the relay may be overcome as shown at Fig. 3. For example, the "C" battery is shown increased to —35 volts, the critical value for maximum sensitivity being —30 volts. The disturbance due to strays, etc. merely reduces the "C" battery voltage to —30 which is not sufficient to cause plate current to flow. However, the signal, being of greater intensity than the strays reduces the voltage to —25, which causes a plate current of 5 milliamperes. It will be seen therefore that all disturbing effects, if of less intensity than the signal, do not affect the relay.

It has been found during the development of this relay that the rectified audio-frequency current in the plate circuit caused the relay armature to vibrate rapidly in the closed position, thus causing a poor contact. This was overcome completely, however by the addition of a one-microfarad condenser 7 across the relay coils. This served the purpose of an audio frequency bi-path for the highly inductive winding of the relay, thus greatly decreasing the resistance of the circuit. The change of plate current due to this audio frequency caused a second change which occurred at the keying frequency. This latter change passes readily through the relay coils and exerts a strong steady pull on the relay armature without the least chattering.

It has also been found that the variable condenser across the secondary 3b of the input audio transformer made possible audio tuning, which increased the selectivity and sensitivity considerably. This tuning was very sharp, and it was found that European stations could be made to operate the relay while a high power station here in the United States would fail to operate it, although the high power station was coming in on the same wave length and slightly stronger. This was made possible by adjusting the heterodyne note of the European station to a frequency different from that of the local station and then tuning the secondary of the audio-transformer to that frequency. The variable condenser may be replaced by a fixed condenser and the audio tuning accomplished by adjusting the heterodyne note to the resonant frequency. By means of this audio tuning one of three sta-

PLAINTIFF'S EXHIBIT No. 1—Continued

tions transmitting simultaneously have been selected and caused to operate the relay though all were of equal intensity. By the use of two recorders operated in series, each working one pen of a double ink register, it was possible to make a simultaneous record of signals made by the spacer wave and sending wave from the U. S. naval high power radio station at Annapolis, Md., at a distant receiving station.

Tests showed that with a signal strength sufficient to produce a plate current of 10 milliamperes, the relay could be operated at a speed of 48 contacts per second, the contact being sufficient to operate a buzzer. With three milliamperes in the plate circuit, a speed of 27 contacts per second was obtained. With one milliampere a speed of 19 per second. In each case the relay armature spring tension was adjusted for the best operation.

The relay is adapted to have all the parts mounted within a readily portable cabinet, and provided with plug connections for direct connection of the apparatus to the lighting circuit power supply, and in the absence of such power binding posts for "A", "B" and "C" batteries are provided so that the relay may be operated in places where the AC supply is not available.

The apparatus may be operated in a combination system as shown in Fig. 4, wherein two different mechanical relays 8 and 8ª of similar construction are arranged to actuate a common armature 8ᵇ. The armature may be mounted to swing in opposite directions in accordance with the pull of the diametrically opposed mechanical relay magnets 8 and 8ª, connected in the output circuits of two different vacuum tube relay equipments. The terminals 32 and 33 go to said output circuit of one relay and the terminals 38 and 39 go to the output circuit of another similar relay. The terminals 32 and 38 go to the plates of the relay vacuum tubes and 33 and 39 to the source of plate voltage.

Contacts closed by the armature at 34 and 35 in its movement to either side from its normal midway position permits the closing of a variety of work circuits. Adjustment springs at 36 and 37 hold the armature normally in the midway position between the two contacts 34 and 35.

This method may be used to render a crossed coil radio direction finder a direct reading and self setting device similar to a magnetic compass or it may be used to hold a moving object on a given course when used in conjuction with an equi-signal crossed coil directional transmitter.

Having thus described my invention, what I claim and desire to secure by Letters Patent of the United States is as follows:

1. The combination in a signal receiving system of a source of audio frequency signals, a plurality of thermionic vacuum tubes having grid, filament and plate electrodes, an audio frequency input circuit including each of said grid electrodes and an output circuit including each of said plate electrodes, a source of alternating current power supply, means associated with said alternating current power supply for impressing a negative potential on said grid electrodes, and a positive potential on said plate electrodes and energizing said filament electrodes and a relay in said output circuit and arranged to respond to said source of audio frequency signals.

2. The combination in a signal receiving system of a source of audio frequency signals, a plurality of thermionic vacuum tubes having grid, filament and plate electrodes, connections between the respective electrodes of said tubes, an audio frequency input circuit, an output circuit, means for selectively tuning said input circuit, a source of alternating current power supply, means for energizing said filaments, a rectifier adapted to supply a negative potential to said grid electrodes from said source of alternating current, a rectifier adapted to apply a positive potential to the plate electrodes in said output circuit from said source of alternating current, and a mechanical relay in said output circuit actuated by said audio frequency signals.

3. The combination in a signal receiving system of a source of audio frequency signals, a thermionic vacuum tube having a grid, filament and plate electrode, an audio frequency input circuit, an output circuit, a source of alternating current power supply, means for energizing said filament, a rectifier adapted to supply a negative potential to the grid electrode in said input circuit, a condenser and a resistance parallelly connected across the output of said rectifier, a second rectifier adapted to apply a positive potential to the plate electrode of said output circuit from said source of alternating current, a condenser connected across the output of said rectifier and a mechanical relay in said output circuit actuated by said audio frequency signals.

4. The combination in a signal receiving system of a source of audio frequency signals, a plurality of thermionic vacuum tubes having grid, filament and plate electrodes, connections between the respective electrodes of said tubes, an audio frequency input circuit including said grid electrodes, an output circuit including said plate electrodes, means for selectively tuning said input circuit, a source of alternating current power supply, means for energizing said filaments, a rectifier adapted to supply a negative potential to said grid electrodes from said source of alternating current, means for smoothing out the energy delivered by said

PLAINTIFF'S EXHIBIT No. 1—Continued

rectifier, a second rectifier adapted to positively energize said plate electrodes from said source of alternating current, means for smoothing out the energy delivered to said output circuit and a mechanical relay in said output circuit actuated by the audio frequency signals selected by said input circuit.

5. The combination in a signal receiving system of a source of audio frequency signals, a plurality of thermionic vacuum tubes having grid, filament and plate electrodes, an audio frequency input circuit, means in said input circuit for discriminating against signals of undesired frequency and selectively receiving signals of a desired frequency, an output circuit, a source of alternating current power supply, means for energizing said filaments, rectifiers comprising valves containing heated and cold electrodes for negatively charging the grid electrodes and positively charging the plate electrodes of said input and output circuits from said source of alternating current, means for varying said energy, means for smoothing out the energy delivered by said rectifiers and a mechanical relay in said output circuit actuated by the audio frequency signals selected by said means in said input circuit.

6. The combination in a signal receiving system of a source of audio frequency signals, a plurality of thermionic vacuum tubes having grid, filament, and plate electrodes, an audio frequency input circuit, an output circuit, means for sharply tuning said input circuit to a selected audio note, a source of alternating current power supply, means for energizing said filaments, a two electrode rectifier adapted to supply a negative potential to the grid electrodes of said input circuit from said source of alternating current, means for smoothing out the energy delivered by said rectifier, a second two electrode rectifier adapted to positively charge the plate electrodes of said output circuit from said source of alternating current, means for smoothing out the energy delivered to said output circuit and a mechanical relay in said output circuit actuated by said audio frequency signals at the selected audio note distinguished by said input circuit.

7. The combination in a signal receiving system of a source of audio frequency signals, a plurality of thermionic vacuum tubes having grid, filament and plate electrodes, an audio frequency input circuit, an output circuit, means connected in shunt with said input circuit for sharply tuning said circuit to a selected tone frequency, a source of alternating current power supply, rectifiers comprising valves containing heated and cold electrodes for impressing negative and positive potentials on said grid and plate electrodes respectively in said input and output circuits from said source of alternating current, means for varying the temperature of said heated electrodes whereby to vary the potential impressed upon said grid and plate electrodes and a mechanical relay in said output circuit actuated by said audio frequency signals at the tone frequency selected by said input circuit.

8. The combination in a signal receiving system of a source of audio frequency signals, a thermionic vacuum tube having grid, filament and plate electrodes, a selectively tuned input circuit, an output circuit, a source of alternating current, a rectifier, means for impressing rectified energy on said grid electrode in said input circuit, a high resistance leak shunted across said rectifier and a mechanical relay in said output circuit actuated by said signals.

9. A signal receiving system comprising in combination an audio frequency amplifier including an electron tube having grid, filament and plate electrodes, an input circuit interlinking said grid and filament electrodes, an output circuit interlinking said plate and filament electrodes, a source of alternating current, means for rectifying said current, means for supplying a negative potential to the grid electrode of said electron tube from said source of alternating current, and means for supplying a positive potential to said plate electrode from said source of alternating current, whereby said audio frequency amplifier operates to amplify signaling energy without interference from said source of alternating current.

10. In a signal receiving system the combination of a source of audio frequency signals, an electron tube having grid, filament and plate electrodes, an input circuit interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, a source of alternating current, independent rectifiers for rectifying said alternating current, connections between one of said rectifiers with said input circuit for impressing a negative potential on said grid electrode, connections between said other rectifier with said output circuit for impressing a positive potential on said plate electrode, and a responsive device connected in the output circuit for actuation by amplified signaling energy.

11. In a direct current supply source for vacuum tubes and the like, the combination of a source of power adapted to be energized by alternating current or the like, means for converting such current into current of constant duration, means for smoothing out fluctuations in such current comprising a filter and a resistance connected across the output side of said filter and output terminals connected at opposite ter-

PLAINTIFF'S EXHIBIT No. 1—Continued

minals of said resistance, said resistance being of such value that the current flowing therethrough is relatively large with respect to the current supplied to the load.

12. A method of energizing thermionic vacuum tubes or the like from a source of alternating current, which comprises rectifying such alternating current to produce fluctuating direct current, filtering out fluctuations from such fluctuating current, passing such filtered currents through a resistance to produce a voltage drop therethrough and impressing the desired portion of such voltage drop upon said thermionic tube.

FRANCIS W. DUNMORE.

PLAINTIFF'S EXHIBIT NO. 2

May 15, 1923. 1,455,141

P. D. LOWELL ET AL

RADIO RECEIVING APPARATUS

Filed March 27, 1922 2 Sheets-Sheet 1

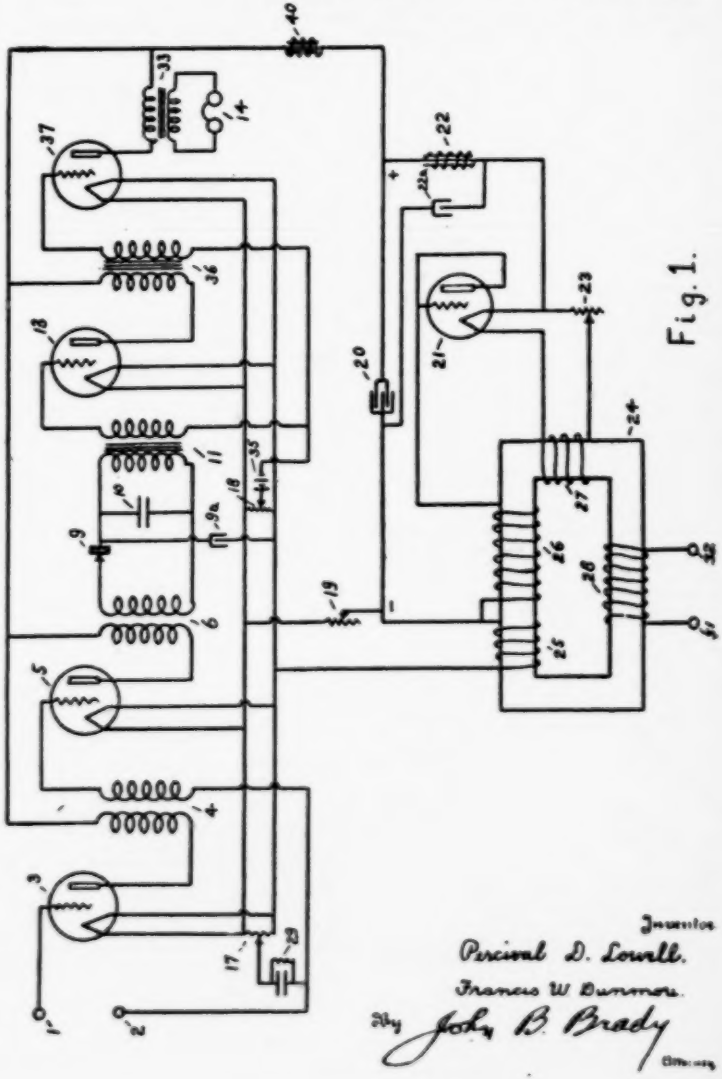

Fig. 1.

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PLAINTIFF'S EXHIBIT No. 2—Continued

Patent No. 1,455,141

May 15, 1923. 1,455,141

P. D. LOWELL ET AL

RADIO RECEIVING APPARATUS

Filed March 27 1922 2 Sheets-Sheet 2

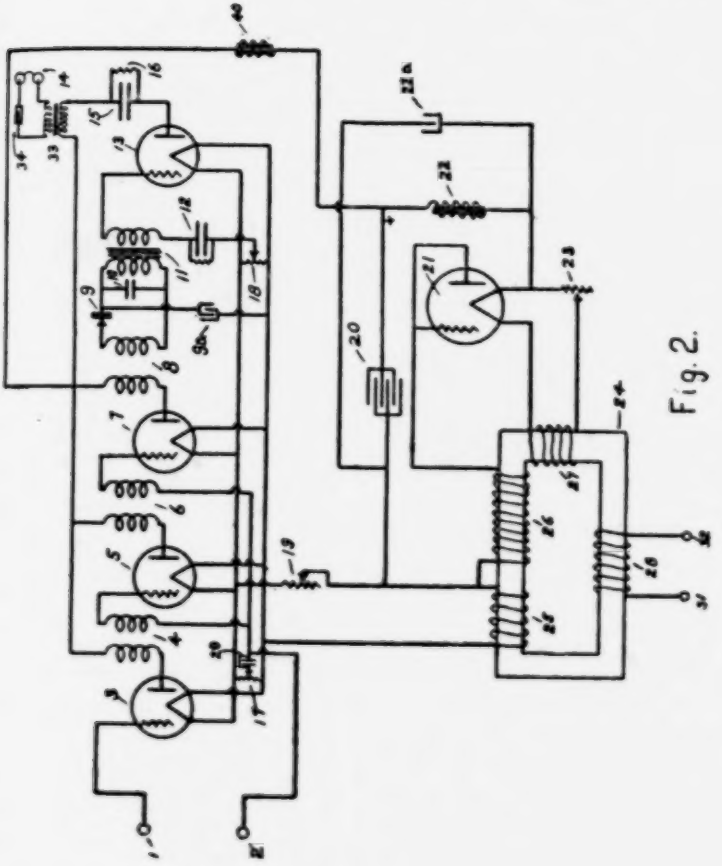

Fig. 2.

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PLAINTIFF'S EXHIBIT No. 2—Continued

Patented May 15, 1923. 1,455,141

UNITED STATES PATENT OFFICE.

PERCIVAL D. LOWELL AND FRANCIS W. DUNMORE, OF WASHINGTON, DISTRICT OF COLUMBIA.

RADIO RECEIVING APPARATUS.

Application filed March 27, 1922. Serial No. 547,111.

To all whom it may concern:

Be it known that we, PERCIVAL D. LOWELL and FRANCIS W. DUNMORE, citizens of the United States, residing at Washington, District of Columbia, have invented certain new and useful Improvements in Radio Receiving Apparatus, of which the following is a specification.

Our invention relates broadly to radio telegraph and telephone receiving apparatus and more particularly to a circuit arrangement for such receivers.

The object of the invention is to provide a receiver unit of maximum sensitivity employing thermionic vacuum tubes with their circuits supplied with energy from the standard alternating current residence lighting power.

Another object of the invention is to provide both radio and audio frequency amplification at the receiver and means for energizing the power circuits of the amplifier stages from the standard alternating current residence lighting power without interference in the reproducing receivers from the hum of the alternating current power supply.

A further object of the invention is to provide a circuit arrangement for a receiver wherein both the radio and audio frequency currents are amplified by means of electron tubes, a crystal detector used as a rectifier, the necessary filament and plate voltages being supplied by the standard alternating current residence lighting power, the residual hum in the telephone receivers being balanced out or neutralized by means of voltage dividers and other devices in the receiver circuits.

A still further object of the invention is to provide means in a radio receiver for transforming the alternating current power supply into currents suitable for the various circuits of the radio and audio frequency stages of the vacuum tube amplifiers and means for rectifying currents and obtaining a steady source of direct current potential for the plate circuits of the vacuum tubes.

Electron tube amplifiers form an important part of practically all radio receiving sets now, except the most simple types. Such amplifiers are in fact necessary to receive distant stations, or when using coil antenna. For good operation, amplifier tubes require for the filament a source of voltage of very constant value (usually about 6 volts) and for the plate a source of voltage of from 40 to perhaps 300 volts. The filament voltage is usually supplied by storage cells, and the plate voltage by dry cells. The maintenance of these cells in operating condition, especially the storage cells, is often a source of much difficulty and annoyance. The storage cells are necessarily bulky and heavy, require constant attention to maintain proper charge and density of electrolyte, give off injurious acid or other fumes, and are subject to considerable variations of voltage during the period of discharge. The development of a receiver employing an amplifier which can be supplied from the ordinary 110-volt alternating current lighting mains is of considerable practical importance, since it eliminates the great practical difficulty of maintaining storage cells. The amplifier using such alternating current supply has the important advantages of reliability, convenience, and cheapness both in first cost and operating cost.

The invention will be more clearly understood by reference to the following specification and the accompanying drawings in which:

Figure 1 is a schematic wiring diagram of a complete receiver embodying two stages of radio frequency amplification, a crystal detector, and two stages of audio frequency amplification; and Fig. 2 is a wiring diagram of a modified form of our receiver including three stages of radio frequency amplification, a crystal detector, and one stage of audio frequency amplification.

It will be understood that the principles of our invention may be embodied in various forms and that details are not material. The present embodiment of the invention, therefore, is to be considered as merely indicative. The form illustrated in the drawing and hereinafter described in detail has been found to be one of the practical embodiments and capable of efficient operation and practical in construction.

The receiver of the present invention is particularly adapted for general use in receiving radio broadcasting concerts, news, lectures, music and messages. The receiver does not require the usual primary or sec-

PLAINTIFF'S EXHIBIT No. 2—Continued

ondary batteries as a source of power for the filament and plate circuits of the vacuum tube amplifiers. A power transformer forms a part of the apparatus and power from the standard alternating current residence lighting circuit is supplied to the primary winding of the transformer. The transformer has a plurality of secondary windings wound in such ratio as to give proportionate current and voltage values as required by the filament and plate circuits of the amplifiers. A rectifier of the two electrode valve type is employed for obtaining a direct current for the plate supply to the tubes and the filament of this valve is also supplied with heating current obtained from one of the proportionate secondary windings of the transformer. The control of the filament temperature of this valve affords means for regulating the potential supplied to the plates of the tubes.

Heretofore in the art successful results have not been obtained by employing the alternating current residence lighting circuit as a source of power supply due to the persistent and predominating interference offered in the reproducing telephones by the hum of the alternating current. We have discovered that this residual hum can be eliminated and in the present receiver the telephones are to all practical purposes absolutely silent as far as any residual hum from the alternating current power supply is concerned. To obtain this result we employ a rectifier of the crystal detector type, although other forms of rectifiers may be readily employed, interposed in circuit after the stages of radio frequency amplification and before the stages of audio frequency amplification. The use of a crystal detector is not as objectionable as it would seem on first consideration, as the radio-audio amplification in association with this form of rectifier makes possible a quick adjustment due to the fact that most any point on a sensitive crystal will bring in a signal of sufficient intensity for all practical purposes. The employment of a crystal detector in place of the electron tube detector reduced the 60-cycle hum very considerably. When an electron tube is used as the detector, there is impressed on both the plate and the filament a 60-cycle A. C. voltage which although small, becomes very objectionable when amplified by one or two stages of audio-frequency amplification. When the crystal detector is used, no 60-cycle voltage is supplied to the detector circuit. The radio-frequency transformer whose output is delivered to the detector circuit prevents the passage in any appreciable amount of 60-cycle current supplied to the radio-frequency stage and such voltages are not present in the crystal detector circuit and do not reach the input of the audio-frequency stage. In predetermined parts of the circuits of the vacuum tube amplifier voltage dividers, balancing resistances, leak resistances, condensers and choke coils are employed to balance out or neutralize any residual hum and prevents its passage into the telephone receivers.

Referring more particularly to Fig. 1 of the drawings a receiver circuit is shown adapted for connection with a variably tuned circuit and thence with an antenna ground system or with a coil antenna. The receiver illustrated comprises an amplifier circuit with two radio frequency stages, a crystal detector and two audio frequency stages. The filaments of all the tubes are connected in parallel and are lighted by alternating current voltage supplied from the secondary winding 25 of the transformer 24, their brilliancy being controlled by the rheostat 19. The primary winding of transformer 24 is shown at 28, the alternating current power supply being connected to the terminals 31 and 32.

Winding 26 of transformer 24 supplies high voltage alternating current which is rectified by the electron tube 21, smoothed out by choke coil 22 and condensers 20 and 22', which are about 2 microfarads capacity. The choke coil 40 may be used as a voltage limiting device in the plate circuit which serves to hold the plate voltage at the proper value regardless of the brilliancy of the electrodes of rectifier tube 21. This provides a high voltage direct current which is suitable for the plates of the amplifier tubes. The filament of the rectifier tube 21 is lighted from winding 27 of transformer 24. The rheostat 23 varies the brilliancy of the rectifier filament, which in turn controls the direct current voltage output.

The input terminals to the amplifier are shown at 1 and 2, being connected to the grid of tube 3 and terminal 2 being connected to the slider of balancing resistance 17 through a grid leak and shunting condenser indicated as a unit at 29, the latter serving to keep the grids of tubes 3 and 5 at the proper operating voltage, making the tube more suitable for amplifying. In the unit 29 the condenser is about 1 microfarad capacity and the shunting resistance is about 1 megohm. The balancing resistance 17 is about 200 ohms and is connected directly across the filament line and serves to stabilize the normal grid voltage. A similar balancing resistance 18 performs a similar function for the grids of tubes 13 and 37. The slider of balancing resistance 18 is connected through a dry battery 35 to grid of tubes 13 and 37. This battery impresses a suitable negative voltage on the grids making the tubes more suitable for amplifying. As this battery furnishes grid voltage only the power consumed is negligible. It is therefore of the small flashlight battery type and will con-

PLAINTIFF'S EXHIBIT No. 2—Continued

tinue effective for a period equivalent to its normal shelf life.

The plate circuit of tube 3 is coupled to the grid circuit of tube 5 by means of the radio frequency transformer 4. There is some variation in the plate current of tube 3 due to the periodic variation in filament temperature but the resultant audio frequency hum does not pass through the radio frequency coupling of transformer 4 and does not reach the input of tube 5.

The secondary of radio transformer 4 is connected to grid of tube 5 and to slider of balancing resistance 17 through condenser and shunting grid leak resistance 29, the resistance 17 keeping the grid voltage steady and the condenser and shunted resistance 29 keeping the grids at the proper negative voltage for amplifying purposes.

The primary winding of radio frequency transformer 6 is connected in the plate circuit of tube 5. The secondary winding of transformer 6 is connected to the crystal detector circuit 9 and includes the primary of audio frequency transformer 11 having a radio frequency by-pass condenser 10 shunted across the winding. The end of primary winding of transformer 11 which is connected to the crystal detector 9 is also connected to the filament circuit through a suitable condenser 9ª of 1 microfarad capacity, this condenser serving to further remove the 60 cycle hum from the telephone receivers. The secondary terminals of this audio transformer 11 are connected to the grid of tube 13 and to slider of balancing resistance 18 through battery 35. Another audio frequency stage is added in a similar manner and is indicated by transformer 36 and tube 37. The telephone receivers 14 may be connected inductively to the plate circuit of tube 37 by means of telephone transformer 32 which has a one to one ratio of windings.

By adjusting the balancing rheostats 17 and 18 the voltage of all the grids may be kept at a steady value and the battery 35 provides the proper negative voltage to the grids of the audio amplifying tubes for the best amplification, while grid leak and condenser 29 serve to keep the grids of tubes 3 and 5 at the best operating voltage.

Fig. 2 shows a modified form of circuit comprising three stages of radio frequency amplification, a crystal detector, and one stage of audio frequency amplification. As in the former case the slider of balancing resistance 17 is connected through a condenser shunted by a leak resistance 29 to the grids of the radio frequency amplifying tubes. The capacity of this condenser is about one microfarad. With this condenser in the circuit as shown, the grids assume a normal voltage suitable for amplifying as derived from winding 25 of transformer 24 while the balancing resistance 17 neutralizes effect of the alternating current on the filaments. The leak resistance across condenser 29 permits any super-charge on the grids to leak off to the filaments. This connection of condenser, high resistance leak and rheostat forms one of the neutralizing means for eliminating the hum of the alternating current from the reproducing telephone receivers.

The grid circuit of the audio frequency amplifier tube 13 is connected to the slider of balancing resistance 18 through condenser and shunted leak 12, which replaces the grid battery 35 used in the former circuit. The condenser 12 is about .02 microfarads capacity.

The purpose of the condenser 12 is to allow the grid of tube 13 to assume a normal voltage suitable for amplifying while the balancing resistance 18 serves to keep the grid voltage steady with respect to the filaments. This forms another of the means for eliminating the alternating current hum from the reproducing telephone receivers.

In series with the plate circuit of tube 13 is a condenser 15 of about .02 microfarads capacity shunted by resistance 16 of about 80,000 ohms. The action of this condenser and resistance is to partially block the low frequency fluctuations in plate current, caused by the periodic change in filament temperature, while the higher frequencies pass through more easily. The 80,000 ohms resistance allows the high voltage direct current to flow to the plate. In the secondary circuit of the telephone transformer 33 and in series with the telephone receivers 14 is shown a condenser 34 of about .02 microfarads capacity which partially blocks any low frequency hum from flowing into the telephone circuit, but which allows the higher frequencies to pass through more easily. The source of filament current and plate voltage is obtained from transformer 24 and two electrode tube rectifier 21 in the manner as described in the circuit arrangement of Fig. 1.

In either of these circuits, instead of the balancing resistance across the filament line, a divided condenser circuit with suitable grid leaks shunted across the condensers may be provided and a connection taken from the center thereof to the grid circuit, or the filament current winding on the transformer may be tapped at its electrical center and lead to the grid circuit. By provision of these neutralizers and the crystal detector rectifier the operator wearing head telephone receivers 14 has no practical interference from the low frequency hum of the alternating current power supply.

The amplifier as above described is adapted to be mounted in a readily portable cabinet which may also contain suitable variable tuning apparatus and the coil aerial,

PLAINTIFF'S EXHIBIT No. 2—Continued

thus making a complete compact, portable, and practical receiving unit. The power transformer is provided with a flexible cord lead and this may be plugged in to a source of standard house lighting current such as 110 volts 60 cycles A. C. The filaments of the tubes are brought up to an electron emitting temperature by rheostat 19. The plate potential is regulated by varying the temperature of the filament of the rectifier tube 21 by varying the rheostat 23. Rheostats 17 and 18 are regulated to adjust the grid-potential and secure neutralization of any disturbing interference from low frequency hum. The crystal detector is adjusted to maximum sensitivity and the radio telephone or telegraph signals reproduced in telephone receivers 14.

While we have described our invention in certain specific embodiments, it will be understood that modifications may be made and that no limitations upon the invention are intended beyond the scope of the appended claims.

What we claim is:

1. In an apparatus for receiving radio signals the combination of a source of signal energy, means for amplifying said energy, means for rectifying said energy, and a source of alternating current for supplying power to said amplifying means and a plurality of means in circuit with said amplifying means for eliminating the hum of said alternating current in said apparatus.

2. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said signals, means for rectifying said signals, a source of alternating current for supplying power to said amplifying means, and means connected to said amplifying and rectifying means for eliminating the hum of said alternating current in said apparatus.

3. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said signal energy at radio frequencies, means for rectifying said energy, means for amplifying said energy at audio frequencies, a source of alternating current for supplying power to said amplifying means and separate means connected to each of said amplifying and rectifying means for eliminating the hum of said alternating current in said apparatus.

4. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said energy at radio frequencies, means for rectifying said energy, means for amplifying said energy at audio frequencies, a reproducer connected to said last amplifying means, a source of alternating current for supplying power to said amplifying means, and means connected to each of said amplifying, rectifying and reproducing means for eliminating the hum of the alternating current in said apparatus.

5. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes arranged to amplify said energy at radio frequencies, a crystal detector arranged to rectify said energy, means for amplifying and reproducing said energy at audio frequencies, a source of alternating current for supplying power to said amplifying means, and a plurality of means for eliminating the hum of said alternating current in said apparatus.

6. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, circuits interconnecting said electrodes whereby said tubes amplify said signal energy at radio frequencies, a crystal detector for rectifying said energy, means for amplifying and reproducing said energy at audio frequencies, a source of alternating current for supplying power to said amplifying means, and means in each of said circuits for eliminating the hum of the alternating current in said apparatus.

7. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said energy at radio frequencies, means for rectifying said energy, means for amplifying and reproducing said energy at audio frequencies, a source of alternating current, means for rectifying said current and supplying the rectified power to the circuits of said amplifying means and separate means in different parts of said circuits for eliminating the hum of the alternating current in said apparatus.

8. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, circuits connecting said amplifiers with said crystal detector, a source of alternating current for supplying power to said amplifiers, and separate means in each of said circuits for eliminating the hum of the alternating current in said apparatus.

9. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, circuits connecting said amplifiers with said crystal detector, a source of alternating current for supplying power to said amplifiers, adjustable means in said amplifier circuits and fixed means connected to said detector circuit for eliminating the hum of said alternating current in said apparatus.

PLAINTIFF'S EXHIBIT No. 2—Continued

10. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier means for reproducing the signal energy, circuits connecting said amplifiers with said crystal detector, a source of alternating current for supplying power to said amplifiers, condensers shunted by resistances connected in said amplifier circuits, and adjustable means for eliminating the hum of said alternating current in said reproducing means.

11. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, a reproducer connected to said audio frequency amplifier, a transformer having a primary winding and a plurality of secondary windings, a source of alternating current connected to said primary winding, said secondary windings being connected to supply power to the circuits of said vacuum tube amplifiers, and hum eliminators connected in different portions of said circuits.

12. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, a reproducer connected to said audio frequency amplifier, a transformer having a primary winding and a plurality of secondary windings, a source of alternating current connected to said primary winding, said secondary windings being connected to supply power to the circuits of said vacuum tube amplifiers, and separate means connected in each of the circuits of said amplifiers, detector and reproducer for eliminating the hum of said alternating current in said apparatus.

13. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a detector, an audio frequency vacuum tube amplifier, a reproducer connected to said audio frequency amplifier, a transformer having a primary winding and a plurality of secondary windings, a source of alternating current connected to said primary winding, means for rectifying energy from one of said secondary windings, means for supplying the rectified energy to the circuits of said vacuum tube amplifiers, and separate means connected in each of the circuits of said amplifiers, detector and reproducer for eliminating the hum of said alternating current in said apparatus.

14. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, circuits interconnecting said electrodes whereby said tubes amplify said signal energy at radio frequencies, a detector for rectifying said energy, vacuum tubes for amplifying said energy at audio frequencies, a source of alternating current, means for supplying said current to the filaments of said tubes, means for rectifying said current and supplying potential to the plate circuits of said tubes, and separate means in each of said circuits for eliminating the hum of the alternating current in said apparatus.

15. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a detector, circuits interconnecting said electrodes and said detector, a transformer having a primary winding connected to a source of alternating current, secondary windings, a two electrode valve rectifier having a filament and a plate, connections between one of said secondary windings and the filament of said rectifier, connections between another of said secondary windings and said rectifier whereby direct current is supplied to the plate circuits of said vacuum tubes, another of said secondary windings connected to supply heating current to the filaments of said vacuum tubes and a capacity and resistance connected in said plate circuits for eliminating the hum of said alternating current in said apparatus.

16. In an apparatus for receiving radio signals the combination of a source of signal energy, means for amplifying said energy, means for rectifying said energy, a source of alternating current for supplying power to said amplifying means, means for rectifying said current, and a plurality of separate means connected in circuit with said rectifying means for smoothing out the rectified current and supplying it to said amplifying means.

17. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a source of alternating current for supplying power to said tubes, a detector for rectifying said signal energy, circuits interconnecting said electrodes and said detector, and an impedance between the filament electrodes of said tubes and said filament electrodes and means in said circuits for eliminating the hum of the alternating current in said apparatus.

18. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a detector, circuits interconnecting said electrodes and said detector, a source of alternating current for supplying power to

PLAINTIFF'S EXHIBIT No. 2—Continued

said circuits, and means connected in circuit with said grid and plate electrodes for eliminating the hum of the alternating current in said apparatus.

19. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a detector, circuits interconnecting said electrodes and said detector, a source of alternating current, a two electrode valve for rectifying said current and supplying the rectified energy to the plate electrodes of said vacuum tubes, and means connected in circuit with said plate electrodes for limiting the potential supplied to said plate circuits from said two electrode valve.

20. In an apparatus for receiving radio signals the combination of a source of signal energy, means for amplifying said energy, means for rectifying said energy, means for reproducing said energy, a source of alternating current for supplying power to said amplifying means, and means connected in circuit with said reproducing means for eliminating the hum of said alternating current in the reproducing means.

21. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a source of alternating current for supplying power to said tubes, a detector for rectifying said signal energy, circuits interconnecting said electrodes and said detector, fixed means in circuit with said grid electrodes and said plate electrodes, and variable means in circuit with said grid electrodes, all of said means serving to eliminate the hum of the alternating current in said apparatus.

PERCIVAL D. LOWELL
FRANCIS W. DUNMORE

PLAINTIFF'S EXHIBIT No. 3

Patent No. 1,606,212

Nov. 9, 1926. 1,606,212

F. W. DUNMORE ET AL

POWER AMPLIFIER

Filed March 21, 1922

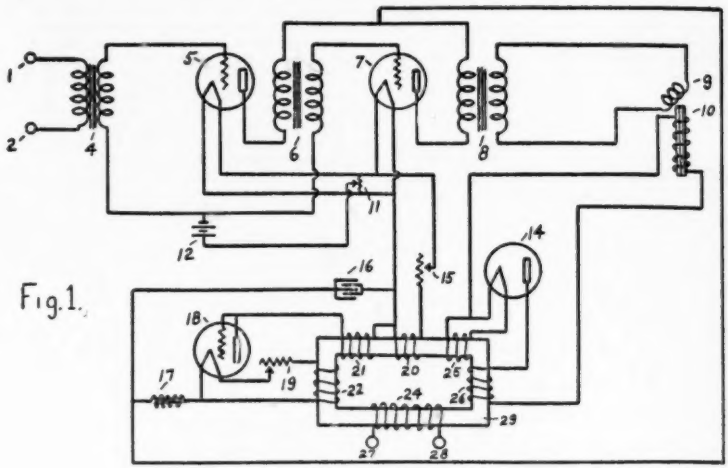

Fig. 1.

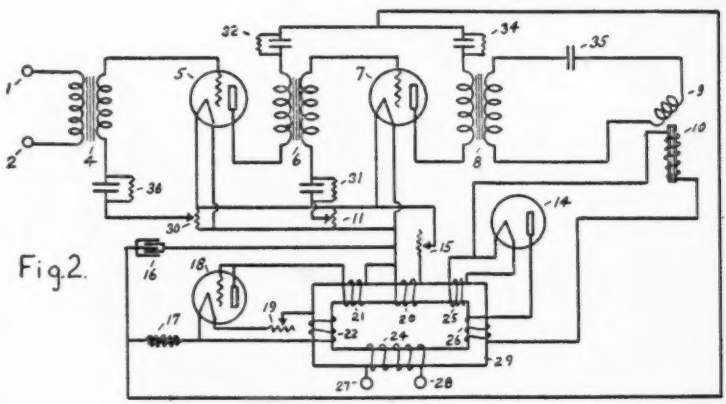

Fig. 2.

Inventor

Francis W. Dunmore

Percival D. Lowell

By John B. Brady

Attorney

PLAINTIFF'S EXHIBIT No. 3—Continued

Patented Nov. 9, 1926. 1,606,212

UNITED STATES PATENT OFFICE.

FRANCIS W. DUNMORE AND PERCIVAL D. LOWELL, OF WASHINGTON, DISTRICT OF COLUMBIA.

POWER AMPLIFIER.

Application filed March 21, 1922. Serial No. 545,493.

Our invention relates to apparatus for the amplification and reproduction of sounds by electrical means and more particularly to an amplifying unit and reproducer of electrical signals.

The object of our invention is to provide an amplifier and reproducer in the form of a readily portable unit.

Another object of our invention is to provide an amplifier of the thermionic vacuum tube type with circuit arrangements for operating the apparatus from the usual source of alternating current residence power supply for energizing the vacuum tube circuits without the use of primary or secondary batteries.

A further object of the invention is to provide a circuit arrangement for a thermionic vacuum tube amplifier employing a loud speaking reproducer in which the loud speaker has its field winding energized from a source of residence lighting power without the use of primary or secondary batteries.

A still further object of the invention is to provide means for eliminating the hum of the low frequency alternating current power supply in the circuits of the thermionic vacuum tube amplifier and reproducer.

Another object of the invention is to provide means for rectifying alternating current and smoothing out the rectified energy to provide a source of power for the circuits of the thermionic vacuum tubes and loud speaking reproducer.

The invention will be more clearly understood by reference to the following specification and accompanying drawings, in which:

Figure 1 is a wiring diagram of the amplifier and electrical reproducer arranged for connection to a source of alternating current power supply with means for eliminating the hum of the alternating current power supply, and Fig. 2 is a modification showing a wiring diagram of the apparatus illustrating means in the thermionic vacuum tube circuits for eliminating the hum of the alternating current power supply.

It will be understood that the principles of our invention may be embodied in various forms and that details are not material. The present embodiment of the invention, therefore, is to be considered as merely indicative. The form illustrated in the drawing and hereinafter described in detail has been found to be one of the practical embodiments and capable of efficient operation and practical in construction.

The apparatus of the present invention comprises a readily portable unit having terminals for the connection of the equipment to any source of electrical variations required to be amplified and electrically reproduced at increased amplitude through a loud speaking telephone. The unit includes a plurality of thermionic vacuum tubes connected in circuit for audio frequency amplification. The loud speaking telephone may be of the type employing a coil armature and electromagnetic field coil. A pair of terminals is provided for the connection of the unit to a source of alternating current power supply as, for example, the usual 110 volt 60 cycle supply. The power is connected to the primary winding of a transformer having proportionate windings thereon for energizing the various circuits of the unit. The filaments of the amplifier tubes are energized from one of these windings. Rectifiers are employed in the unit whereby energy derived from other windings is rectified and supplied as a source of plate circuit potential for the vacuum tube amplifier and as a supply for energizing the field of the loud speaking reproducer. The rectifiers are preferably of the two electrode valve construction and have their filaments energized from other windings on the transformer. Means are provided for biasing the grids of the vacuum tubes comprising the amplifier. Means are also included in the circuits of the amplifier for eliminating the hum from the alternating current power supply and means are included in the equipment for smoothing out the rectified energy supplied to the plate circuits of the amplifier.

Referring to the circuit diagram shown in Figure 1, reference characters 1 and 2 indicate the input terminals of the audio frequency amplifier and lead to the primary winding of the audio frequency transformer 4. The secondary terminals of transformer 4 are connected to the grid of vacuum tube 5 and to the slider of the stabilizing rheostat 11 through battery 12 respectively. The battery 12 connected in series with the slider of rheostat 11 has a potential of about 10 volts so connected that a negative voltage is impressed on the grid of tube 5. The

PLAINTIFF'S EXHIBIT No. 3—Continued

purpose of stabilizer 11 is to keep the normal voltage of the grid at a steady value with respect to the filament and eliminate the hum of the alternating current supply while the negative voltage from battery 12 holds the grid at its best potential for amplifying purposes. As this battery furnishes grid voltage only, the power drawn from it is negligible. It is therefore of the small flash light battery type and will continue effective for a period equivalent to its normal shelf life. The primary winding of audio frequency transformer 6 is connected in the output or plate circuit of vacuum tube 5. The secondary of audio frequency transformer 6 is connected to the grid of tube 7 and to stabilizer 11, with series grid battery 12, functioning the same as in the first stage.

In the output or plate circuit of tube 7 the primary of the telephone transformer 8 is connected, which has a one to one ratio of winding. This transformer also serves to reduce the hum of the alternating current supply. The secondary of this transformer may be connected to any type of loud speaking reproducer. In the present instance a loud speaker having a field winding may be employed and this secondary winding may lead to the primary winding of a stepdown transformer employed with the loud speaker, the secondary winding of which leads to the armature coil 9 as is usual in this instrument.

29 is a transformer having a primary winding 24 to which the 110 volt, 60 cycle A. C. power is applied at terminals 27 and 28. Winding 22 supplies the filament voltage for the rectifier tube 18, rheostat 19 being in series to regulate its brilliancy. Winding 21 supplies high voltage for the plates of the amplifier tubes 5 and 7, said high voltage being rectified by tube 18 and smoothed out by condenser 16 which is about 4 microfarads capacity, and a choke coil 17. This provides a high voltage direct current which is suitable for the plates of the amplifying tubes.

Winding 20 provides the proper voltage for lighting the filaments of the amplifier tubes 5 and 7, and their brilliancy is controlled by rheostat 15.

Reference numeral 10 represents the electro-magnetic field coil of the loud speaker and is excited by low voltage direct current supplied by the tungar rectifier tube 14. The filament of this tube is lighted from winding 25 of transformer 29 and winding 26 supplies the proper voltage which is rectified by tungar tube 14 and applied to the field winding 10.

In spite of the fact that the sole source of power for this circuit is from the 60 cycle alternating current source, there is practically no resultant hum in the loud speaking telephone due to the reactance offered by the winding 10 and the cooperative effect of this winding with the output circuit of the amplifier system. That is to say the inductance of the field coil 10 is selected of such value and the power amplifier is so connected with the winding 9 that pulsations in the field winding are effectively opposite in phase to the phase of the pulsations in the output circuit of the amplifier so that there is a tendency for the disturbing currents to be neutralized as a result of which the armature remains stationary so far as the effects of disturbing current components are concerned.

A modified form of this circuit is shown in Fig. 2, wherein there is a condenser 36 of about .02 microfarads capacity shunted by a leak resistance of about 2 megohms, in series with the slider of the stabilizer 30 in the grid circuit of tube 5. This condenser serves to keep the normal voltage of the grid at a suitable value for amplifying audio frequency energy impressed at terminals 1 and 2, at the same time acting as a partial block to any existing low frequency hum. The leak resistance prevents the grid from becoming supercharged.

In the plate circuit of tube 5, in series with the primary of the audio frequency transformer 6, is a condenser 32 of about .02 microfarads shunted by a resistance of approximately 80,000 ohms. This condenser serves to partially block the 60 cycle hum, but allows the higher frequencies to pass through. The shunt resistance allows the direct current plate voltage to reach the plate around the condenser, but serves as a block to the low frequency hum.

In series with the secondary of the audio frequency transformer 6 in the grid circuit of tube 7 is a .02 microfarad condenser 31 shunted by a 2 megohm resistance. This condenser and leak 31 function the same as condenser and leak 36 in eliminating any low frequency hum.

A .02 microfarad condenser shunted by an 80,000 ohm resistance 34 is in series with the plate circuit of tube 7 and functions in the same manner as condenser and resistance 32 to eliminate any residual low frequency hum.

Condenser 35 is about .005 microfarads capacity and is in series with the secondary of the telephone transformer 8. It also serves as a partial block to any low frequency hum which may be present. The transformer 29 is arranged with terminals 27 and 28 for connection to the usual source of 110 volt A. C. residence lighting power and includes the several proportionate windings for supplying energy to the circuits of the unit as described in Fig. 1.

In the operation of the apparatus terminals 1 and 2 are connected to any source of audio frequency electrical energy to be am-

PLAINTIFF'S EXHIBIT No. 3—Continued

plified and reproduced. The terminals 1 and 2 may be connected to the output circuit of a detector tube in a radio receiver. Terminals 27 and 28 are connected through a flexible cord plug with the residence lighting circuit. Rheostat 15 is regulated to secure the proper filament temperature of the amplifier tubes. Rheostat 19 is regulated to secure the proper plate potential for the amplifying tubes. The sliders of rheostats 11 and 30 are adjusted to an electrical midpoint in the resistance, at which point the voltage impressed on the grid of tubes 5 and 7 from the A. C. supply is steady or of very small value. By this adjustment the hum is eliminated from the reproducer circuits. The audio frequency energy variations supplied to terminals 1 and 2 are reproduced at great volume of sound by the reproducer comprising windings 9 and 10.

It will be understood that we are not limited to the use of a reproducer employing a field winding but that any type of reproducer may be employed The disturbing pulsations which may be present in the winding 9 are of opposite phase by virtue of the phase shifting circuit 8—9, than the phase of disturbing pulsations or currents in the winding 10. The mutual effect therefore is nil as the pulsations tend to be neutralized and have no effect upon the armature.

The entire equipment, including the reproducing horn of the loud speaker, is adapted for mounting within a readily portable cabinet.

Having thus described our invention what we claim and desire to secure by Letters Patent of the United States is as follows:

1. In an apparatus for the reproduction of sound, the combination of a thermionic vacuum tube amplifier circuit, a power source of alternating current, means for rectifying said current, means for supplying the rectified current to said vacuum tube amplifier circuit, a loud speaker reproduced of the electrodynamic type connected to said amplifier, and means for supplying rectified current to said reproducer.

2. In an apparatus for the reproduction of sound, a thermionic vacuum tube amplifier, an input circuit, an output circuit, a power source of alternating current, means for rectifying said current, a loud speaker reproducer connected in said output circuit and comprising an armature winding and a field winding and circuits for supplying said rectified current to said output circuit and to said field winding, said windings being connected in such relation that disturbing current effects in said loud speaker reproducer are substantially eliminated.

3. In an apparatus for the reproduction of sound, a thermionic vacuum tube amplifier, an input circuit and an output circuit, a loud speaker reproducer comprising an armature winding and a field winding, connections between said output circuit and said armature winding, a power source of alternating current, means for rectifying said current and supplying said rectified current to said output circuit and to said field winding, said windings being so connected with said means as to substantially oppose the effect of disturbing currents in said loud speaker reproducer.

4. In an apparatus for the reproduction of sound, a thermionic vacuum tube amplifier, an input circuit, an output circuit, a power source of alternating current, a plurality of means for rectifying said current, filters for smoothing out the rectified current and supplying said rectified current to said output circuit, means in said output circuit for reproducing the signal energy and connections whereby one of said rectifiers supplies energy to said reproducing means, said reproducing means being arranged to substantially neutralize disturbing currents.

5. In an apparatus for the reproduction of sound, a thermionic vacuum tube amplifier, an input circuit, and output circuit, a loud speaker reproducer comprising an armature winding and a field winding, connections between said output circuit and said armature winding, a power source of alternating current, means for rectifying said current, means for smoothing out the rectified current and supplying said current to said output circuit and said field winding with the alternating current components thereof in phase opposition whereby the effect of said alternating current components on said loud speaker reproducer are substantially eliminated.

6. In an apparatus for the reproduction of sound, a thermionic vacuum tube amplifier, an input circuit, an output circuit, a power source of alternating current, means for rectifying said current, filters for reducing the hum of the rectified current, and supplying said rectified current to said output circuit, a loud speaker in said output circuit for reproducing the signal energy and means connected to said loud speaker and associated with said power source for opposing the residual hum of the rectified current.

7. A sound reproducing apparatus comprising in combination an electron tube amplification system including a filament heating circuit, an output circuit, a loud speaker sound reproducer having a pair of windings, one of said windings connected with said output circuit, and connected to a source of alternating current, a device for rectifying a portion of said current for supplying the rectified current to the other of said aforementioned windings, means for deriving

PLAINTIFF'S EXHIBIT No. 3—Continued

power from said source for energizing said filament heating circuit and said output circuit, said first mentioned winding being connected with said output circuit in such manner that interfering current pulsations occur therein in substantially opposite phase with respect to interfering current pulsations in said second winding for neutralizing the effects of said interfering current pulsations upon said sound reproducing apparatus.

8. An electromagnetic sound reproducing system comprising in combination a power amplifier having circuits arranged to be excited from a power source of alternating current, a loud speaker reproducer including a circuit energized from said power source and a circuit connected with said power amplifier, said last mentioned circuit including a condenser and a transformer having primary and secondary windings with the primary winding connected with said power amplifier and said secondary winding connected with said reproducer and arranged in such manner that alternating current components existent in said circuits occur in substantially opposite phase whereby the effects of said alternating current components on said loud speaker reproducer are substantially neutralized.

9. In a sound reproducing apparatus the combination of an amplifier, a loud speaker having armature and field winding with said armature winding connected to the output of said amplifier, an alterating current supply source, means for deriving power from said source for energizing the circuits of said amplifier, filter circuits for reducing the hum of said alternating current in said apparatus and means for supplying power from said source to said field winding in such manner that the residual hum in said field winding will oppose the residual hum in said armature winding for eliminating the hum of said alternating current in said apparatus.

FRANCIS W. DUNMORE.
PERCIVAL D LOWELL.

Certificate of Correction.

It is hereby certified that in Letters Patent No 1,606,212, granted November 9, 1926, upon the application of Francis W Dunmore and Percival D Lowell, of Washington, District of Columbia, for an improvement in "Power Amplifiers," errors appear in the printed specification requiring correction as follows: Page 3, line 46, claim 1, for the word "reproduced" read *reproducer*, and line 93, claim 5, for the word "and" read *an;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of December, A. D. 1926.

[SEAL.]

M. J. MOORE,
Acting Commissioner of Patents.

PLAINTIFF'S EXHIBIT No. 4

Certified copy of file wrapper and contents relating to Patent No. 1,635,117. (Not printed. Made physical exhibit by stipulation.)

PLAINTIFF'S EXHIBIT No. 5

Certified copy of file wrapper and contents relating to Patent No. 1,455,141. (Not printed. Made physical exhibit by stipulation.)

PLAINTIFF'S EXHIBIT No. 6

Certified copy of file wrapper and contents relating to Patent No. 1,606,212. (Not printed. Made physical exhibit by stipulation.)

PLAINTIFF'S EXHIBIT No. 7

License agreement relating to Patent No. 1,455,141 granted to Dubilier Condenser & Radio Corporation by Francis W. Dunmore and Percival D. Lowell.

EXCLUSIVE LICENSE AGREEMENT

Memorandum of agreement made and entered into this 20th day of October, 1924, by and between Dubilier Condenser & Radio Corporation, a corporation of the State of Delaware, having a place of business at 48 West Fourth Street, city, county, and State of New York (hereinafter called Dubilier), and Francis W. Dunmore and Percival D. Lowell, whose address is c/o John B. Brady, Ouray Building, Washington, D. C. (hereinafter called the Inventors), Witnesseth:

Whereas, the inventors have made certain inventions relating to electron tube radio receiving apparatus wherein circuits of the electron tubes are supplied from the ordinary house lighting current without the employment of primary or secondary batteries, for which they have obtained United States Letters Patent No. 1,455,141, dated May 15, 1923, and entitled Radio Receiving Apparatus; and

Whereas, Dubilier is desirous of acquiring an exclusive license to manufacture, use, and sell the aforesaid invention, such modifications thereof and improvements thereon as the inventors have heretofore made or may hereafter make, together with the right to con-

PLAINTIFF'S EXHIBIT No. 7—Continued

trol all future licenses that may be granted as hereinafter more fully set forth:

(X) Now, therefore, for and in consideration of the premises and the covenants hereinafter cited and to be faithfully performed, and the sum of five thousand ($5,000.00) dollars by Dubilier to the inventors in hand paid as advance royalties, the receipt of which is hereby acknowledged, it is understood and agreed as follows:

1. The inventors covenant that they are the sole and exclusive owner of the aforesaid invention, modifications, and improvements thereof, and the patent covering the same, and that they have the full right to enter into this agreement, except for the following licenses, true copies of which are annexed hereto and form part hereof:

(a) Nonexclusive, personal, nontransferable license to the Timmons Radio Products Company.

(b) Nonexclusive, personal, nontransferable license to the United States Government for governmental purposes only.

2. The inventors further reserve to themselves the right to grant the following licenses, it being understood and agreed, however, that the said licenses and each of them shall contain the following clause:

(Y) This license is granted and this agreement entered into with the express understanding that all fixed condensers used in the manufacture of apparatus under the aforesaid patent shall be purchased from Dubilier Condenser & Radio Corporation, 48 West Fourth Street, New York, and violation of this covenant will render this contract null and void and all rights granted by licensors to licensee shall be discontinued.

Each license shall also be granted only upon the payment of the initial sum mentioned below in the nature of advance royalty and with the royalty per device fixed, as stated:

(a) A nonexclusive, personal, nontransferable license to the Pathe Phonograph & Radio Corporation, upon the payment of one thousand ($1,000) dollars advance royalty and a specific royalty of fifty cents (50¢) per device.

(b) A nonexclusive, personal, nontransferable license limited to the use of the invention only in connection with time clock mechanisms to the International Time Recording Company upon payment of five hundred ($500) dollars advance royalties and a specific

PLAINTIFF'S EXHIBIT NO. 7—Continued

royalty of one ($1.00) dollar per device. Broadcasting reception expressly excluded.

(c) A nonexclusive, personal, nontransferable license to C. Brandes, Inc., upon payment of one thousand ($1,000) dollars advance royalties, and a specific royalty of fifty cents (50¢) per device.

(d) A non-exclusive, personal, non-transferable license for use of the invention only in connection with wired wireless to Wired Radio, Inc., upon payment of one thousand ($1,000) dollars advance royalty and a specific royalty of fifty cents (50¢) per device. Regular broadcasting reception expressly excluded.

3. The inventors hereby covenant and agree that copies of the foregoing licenses shall be submitted to Dubilier before the execution thereof and if said licenses are entered into, the inventors further covenant and agree that upon failure of their licensees to comply with the clause relating to the purchase by said licensees of condensers from Dubilier, that the inventors will forthwith revoke said licenses unless the same are continued by written permission so to do to the inventors from Dubilier.

4. It is mutually understood and agreed that should any licensee under the said patent No. 1,455,141 be sued, or threatened with suit under letters patent held by an adversary, that the inventors and Dubilier each shall have the independent right to grant a free, nonexclusive license to such adversary in consideration of a similar license under said adversary's patent, or upon such other terms as the parties hereto mutually agree upon, it being expressly agreed, however, that each party shall keep the other fully informed in the matter, and that each shall safeguard the other, the intent and purpose of this covenant being to provide that all licensees shall be maintained immune from damages arising out of any attack for infringement insofar as the inventors and Dubilier may be able to quiet said attack by licensing the adversary.

5. Subject to the foregoing licenses and rights, the inventors hereby give and grant to Dubilier, its successors and assigns, the exclusive right to manufacture, use, and sell and to grant to others the right to manufacture, use, and sell the aforesaid invention and any and all modifications thereof and improvements thereon that they have heretofore made or may hereafter make throughout the United States, its Territories and dependencies, and covenant to grant to Dubilier, or its nominee or nominees, the exclusive right to manufacture, use, and sell, and to grant to others the right to manufac-

PLAINTIFF'S EXHIBIT No. 7—Continued

ture, use, and sell said invention, modification, and improvement in each and every foreign country where such invention or improvement, or both, may be covered by letters patent.

6. The inventors, during the life of this agreement, shall promptly file and diligently prosecute at their own expense any reissue of said United States letters patent, as the said inventors and Dubilier may agree are necessary and desirable to adequately protect the said invention. The inventors will keep Dubilier informed respecting all proceedings in the United States Patent Office in connection with said reissue, interference, or any other proceeding that may therein arise and to consult Dubilier before taking any action that may detrimentally affect its interests.

7. Dubilier shall bear the expense of filing and prosecuting any applications for letters patent upon the aforesaid invention, modification, and improvement, as it may elect to file in foreign countries and the expense of maintenance of all letters patent that may be granted upon such applications, and hereby agrees to give to the inventors timely written notice as to all foreign countries in which it elects to file applications for letters patent.

8. The inventors shall execute all papers that may be necessary or desirable to enable Dubilier, or its nominee or nominees, to file and prosecute applications for letters patent in all countries in which Dubilier shall elect to secure patent protection for said invention, and to prosecute all suits thereunder.

9. Dubilier covenants to pay to the inventors during the life of this agreement the following royalties:

(A) Fifty cents per apparatus or device, until a total of five thousand ($5,000) dollars has been credited by the inventors to Dubilier, this covering the five thousand ($5,000) dollars advance royalty paid as consideration for the making of this agreement. (Paragraph (X) page 1 hereof.)

(B) Fifty cents per apparatus or device, until a total of ten thousand ($10,000) dollars has been paid.

(C) On the next succeeding 60,000 devices, a royalty of twenty-five cents (25¢) each.

(D) On the next succeeding 100,000 devices, a royalty of twenty cents (20¢) each.

(E) On the next succeeding 200,000 devices, a royalty of fifteen cents (15¢) each.

(F) On all devices thereafter, a royalty of ten cents (10¢) each.

PLAINTIFF'S EXHIBIT NO. 7—Continued

10. Dubilier further covenants to pay to the inventors any sum or sums of money that may accrue to Dubilier from any license hereafter granted by Dubilier in accordance with the provisions of this agreement, said sum to apply on the ten thousand ($10,000) dollar payment specified in paragraph 9 B above. At any time the payment of said ten thousand ($10,000) dollars is liquidated by Dubilier by monies accruing from sub-licenses or otherwise, then the royalty of fifty cents (50¢) per device mentioned in said paragraph 9 B, shall be discontinued and the royalties thereafter accruing to Dubilier from licensees shall be divided as provided in paragraph 22 hereof.

11. Should this agreement be terminated for any cause whatsoever prior to the expiration of the patent mentioned herein, Dubilier covenants and agrees to assign to said inventors any and all outstanding licenses it may have granted hereunder, and shall not thereafter be liable to said inventors for any royalties due by said licenses after the date of said assignment.

12. For the purpose of determining the amount of royalties, the terms "apparatus" and "device" used herein are understood to refer to and include the following:

(a) A device for supplying filament current to radio receiving sets, replacing the usual A battery.

(b) A device for supplying plate current to radio receiving sets, replacing the usual B battery.

(c) A combination device for supplying both A and B battery for radio receiving sets.

(d) Apparatus embodying either (a), (b), or (c).

13. Only one royalty payment shall be made on account of a single complete apparatus or device and Dubilier shall not be liable for royalties upon any apparatus returned by purchasers for credit and shall have the right to deduct the amount of any such royalties already paid from the amount of the royalties that may subsequently accrue. No royalty shall be paid on the parts of apparatus that are sold as repairs or furnished as replacements.

14. In case the royalties accruing to the inventors upon apparatus or devices manufactured and sold or used by Dubilier and its nominees or licensees during any calendar year of the life of this agreement shall not amount to five thousand ($5,000.00) dollars, or in case Dubilier otherwise fails to perform any of its obligations herein prescribed, the inventors shall have the right upon sixty days written notice by registered mail delivered to Dubiler, to terminate this agreement, it being understood that Dubilier shall be liable for all

PLAINTIFF'S EXHIBIT No. 7—Continued

royalties that may have accrued prior to the date of actual termination of the agreement. However, if the said notice is given because the royalties accrued and paid do not amount to the above specified sum, Dubilier may, after receipt of such notice, continue this agreement in full force and effect by making good the deficiency prior to the expiration of the said period of sixty days.

15. Dubilier covenants to pay the royalties due under this agreement to the inventors in semi-annual payments on June thirtieth and January thirtieth, the said payments to include all royalties due and payable up to within thirty days of the said dates.

16. Dubilier shall keep and shall require its nominees and licensees to keep proper books of account with reference to all apparatus which it or they may manufacture and sell, embodying the aforesaid invention, modifications, and improvements and shall render semi-annual statements or extracts from said books to the inventors showing the total amount of such apparatus as may have been manufactured and sold during the preceding royalty period and the amount of royalties payable to the inventors, the said statements to be rendered at the time of making the royalty payments designated in paragraph 15 hereof. Dubilier shall, when requested by the inventors so to do, verify the said statements by affidavits and shall also permit and require its nominees and licensees to permit the inventors, through a certified public accountant, to inspect such books of account and to make extracts therefrom at reasonable times, said accountant to be paid by the inventors.

17. Dubilier shall use every reasonable endeavor to mark and to have its nominees and licensees mark all apparatus covered by the aforesaid patent and any others that may come within the scope of this agreement which is manufactured and sold by it or them with the dates thereof.

18. The inventors hereby agree, subject to the direction and approval of Dubilier, to conduct such proceedings as may be considered necessary and desirable to enforce the said United States letters patent against alleged infringers and for this purpose, it is mutually agreed that John B. Brady, Esq., of Washington, D. C., shall be appointed a trustee to receive a trust fund consisting of ten per cent (10%) of all monies received by the said inventors from all sources arising out of the licensing of said United States letters patent, which they hereby agree to pay into said Brady, the same to be used as a fund for the legal expenses incident to the defense of suits

PLAINTIFF'S EXHIBIT No. 7—Continued

that may be brought by others against Dubilier or the inventors, or both of them, or their respective licensees, and also for the purpose of paying the necessary and proper legal expenses incident to the prosecution of infringers of the said patent, it being understood that all expenses shall be paid out of the said fund and in the event that the said fund is insufficient, then the inventors and Dubilier shall divide the said expenses equally between them provided they mutually so consent to do.

It is also mutually understood and agreed that when the said trust fund shall total the sum of five thousand ($5,000) dollars that payments into the same may be discontinued, to be resumed when necessary to re-establish the aforesaid account.

It is further mutually understood and agreed that the said trust fund may at any time be used for any purpose mutually agreed upon by the parties hereto.

19. The inventors hereby give and grant to Dubilier the right to sue in its own name and at its own expense any infringers of said patent or patents and to collect for its own use and behoof such damages and profits as may be assessed as the result of such suit or suits, provided, however, that in all cases where the inventors wish to join in any suit or suits they shall have the right so to do, in which event the expenses shall be paid out of said trust fund and Dubilier and the inventors shall then share equally in the division of all monies received, as damages or profits that may be collected.

20. The inventors hereby specifically grant to Dubilier the right to grant sub-licenses to others under the aforesaid patent, or any other patents that may come within the scope of this agreement, it being understood that Dubilier shall have the right to insert in said licenses, if it so desires, a paragraph similar to that of paragraph 2Y hereof, requiring use by the licensee of Dubilier condensers.

a. It is also agreed that Dubilier shall have the right to include the total number of devices made by Dubilier licensees, with the total number of devices made by Dubilier in computing the total number of devices for the purpose of making royalty payments thereon, as specified in paragraph 9 hereof.

21. Dubilier hereby covenants and agrees to pay to the inventors one-half of all sums received from any license that may be granted by Dubilier, it being mutually understood and agreed that the inventors shall pay into the trust fund, paragraph 18 above, ten per cent of all such money received from Dubilier as well as ten per cent of all monies received from Dubilier as royalties from the manufacture and/or sale of apparatus.

PLAINTIFF'S EXHIBIT No. 7—Continued

22. Dubilier hereby covenants and agrees to pay into the trust fund as set forth in paragraph 18 hereof, ten per cent of all monies received from sub-licensees, the following procedure being mutually agreed upon in this connection:

(a) Dubilier or its nominees shall collect royalties due under all licenses granted by Dubilier.

(b) The said royalties so collected shall be divided equally between Dubilier and the inventors.

(c) Dubilier shall pay ten per cent of the amount received to the trust fund, paragraph 18 hereof.

(d) The inventors shall pay ten per cent to the trust fund, paragraph 18 hereof.

23. If, as a result of court decisions substantial protection for the main subject-matter of this agreement is not afforded by said patent or if adversely held patents are declared to prevent manufacture of devices under said patent, Dubilier may terminate this agreement if it shall so elect.

24. In case of the termination of this agreement, for any cause whatsoever, all rights and obligations of the parties hereunder shall cease and their original rights of prosecution and defense of infringement suits shall be restored.

25. If any controversy shall arise between the parties as to the performance of any obligation under this agreement, the matter in controversy shall be submitted, at the option of either party, to three arbitrators who shall have power to decide the matter in controversy, and to determine what, if any, amount shall be paid by either party to the other as liquidated damages for any breach of this agreement, and each party agrees to pay to the other any damages that may be assessed by the arbitrators. Upon such contingency, each party shall designate one arbitrator, and these two shall appoint a third arbitrator. The expense of the arbitration shall be borne by the losing party or apportioned between the parties as the arbitrators may direct.

26. This agreement and the covenants herein contained shall be binding upon, and inure to the benefit of, the heirs, executors, administrators, successors, and assigns of the parties hereto.

27. Dubilier agrees under this license not to enter into the manufacture of apparatus of this invention within an area of ten miles of Philadelphia and agrees further not to grant licenses to others engaging in such manufacture in said area without the consent of the inventors.

PLAINTIFF'S EXHIBIT No. 7—Continued

In witness whereof, Dubilier has caused these presents to be signed by its proper officer, and the inventors have hereunto set their hands and seals the day and year first above written.

[SEAL.] DUBILIER CONDENSER & RADIO CORPORATION,
By H. R. VAN DEVENTER,
Vice President.

Attest:
U. S. HOWARD, *Secy.*

Dubilier Condenser & Radio Corporation Corporate Seal. 1922. Delaware.

PERCIVAL D. LOWELL. [SEAL.]

Witness:
RALPH R. BATCHER.

FRANCIS W. DUNMORE. [SEAL.]

Witness:
J. HAROLD MORGAN.

PLAINTIFF'S EXHIBIT No. 8

License agreement relating to Patent No. 1,606,212 granted to Dubilier Condenser Corporation by Francis W. Dunmore and Percival D. Lowell

AGREEMENT

Memorandum of agreement made and entered into this 19th day of May, 1927, by and between Dubilier Condenser Corporation, a corporation organized under the laws of the State of Delaware, having its principal office and place of business at 4377 Bronx Boulevard, county of Bronx, city and State of New York (hereinafter called "Dubilier"), and Francis W. Dunmore, of the city of Washington, District of Columbia, and Percival D. Lowell, of Richmond Hill, in the State of New York (hereinafter called the "inventors").

Witnesseth:

Whereas heretofore and on the 20th day of October, 1924, the inventors made and entered into a certain agreement in writing with Dubilier, concerning Letters Patent 1,455,141 granted to the inventors on May 15, 1923, and entitled "Radio Receiving Apparatus"; and

Whereas the inventors have obtained a further patent entitled "Power amplifiers" under date of November 9, 1926, known as No. 1,606,212, based on an application filed March 21, 1922, as Serial

PLAINTIFF'S EXHIBIT No. 8—Continued

No. 545,493, and which is separate and apart from Letters Patent No. 1,455,141, embraced by the aforementioned agreement; and

Whereas Lowell, one of said inventors, has filed applications for improvements on the invention covered by said Letters Patent 1,455,141, which applications are serially numbered 2214 and 2215, and bear a filing date of January 13, 1925.

Whereas Dubilier is desirous of acquiring a license to manufacture, use, and sell apparatus embodying the inventions of both aforesaid letters patent and said pending applications, and such modifications thereof and improvements thereon as the inventors have heretofore made or may hereafter make, together with the right to control all future licenses that may be granted, as hereinafter more fully set forth:

Now, therefore, for and in consideration of the premises and the mutual promises and covenants by each of the parties hereto, to the other hereinafter made, and the sum of $1,984.03 by Dubilier to the inventors in hand paid, the receipt whereof is hereby acknowledged, the parties hereto do hereby agree each with the other as follows:

First. Nothing in this agreement hereinafter contained shall be in any wise construed to avoid, affect, modify, or in any wise alter any action that may have been taken by either party to the agreement between Dubilier and the inventors made and entered into on October 20, 1924, as hereinbefore recited.

Second. The inventors covenant that they are the sole and exclusive owners of the aforesaid inventions and each of them and the patents and applications covering the same, and that they have full right to enter into this agreement, except for the following licenses which have already been granted by them, to wit:

(a) A nonexclusive, nontransferable license to the Timmons Radio Products Corporation covering Letters Patent 1,455,141 only;

(b) A nonexclusive, personal, nontransferable license to the United States Government for governmental purposes only, which arises out of the employment of the inventors by the Government and is implied by such employment.

Third. The inventors hereby further reserve the right to grant the following licenses under the said patents and applications upon payment of the initial sum mentioned below in the nature of advance royalty and with the royalty per device fixed as hereinafter set forth or upon terms not less favorable to the inventors and to Dubilier than the terms which are hereinafter described and which the inventors are privileged to arrange with the prospective licensees, to wit:

PLAINTIFF'S EXHIBIT No. 8—Continued

(a) A nonexclusive, personal, nontransferable license to the Pathe Phonograph & Radio Corporation or its nominees, upon the payment of one thousand dollars ($1,000) advance royalty and a specific royalty of fifty cents (50c) per device;

(b) A nonexclusive, personal, nontransferable license limited to the use of the invention only in connection with the clock mechanisms to the International Time Recording Company upon payment of five hundred dollars ($500) advance royalty and a specific royalty of one dollar ($1.00) per device;

(c) A nonexclusive, personal, nontransferable license to Brandes Products Corporation upon payment of one thousand dollars ($1,000) advance royalty, and a specific royalty of fifty cents (50¢) per device;

(d) A nonexclusive, personal, nontransferable license for use of invention, only in connection with wired wireless to Wired Radio, Inc., upon payment of one thousand dollars ($1,000) advance royalty and a specific royalty of fifty cents (50c) per device;

(e) A nonexclusive, personal, nontransferable license to Timmons Radio Corporation upon payment of one thousand dollars ($1,000) advance royalty and a specific royalty of fifty cents (50¢) per device, under Letters Patent 1,606,212 and applications Nos. 2214 and 2215 for the manufacture of power amplifiers and loud speakers in addition to the license heretofore granted to said company under Letters Patent 1,455,141 hereinbefore referred to, but with respect only to the license to be granted under Letters Patent 1,606,212 the same shall not contain the restrictions, limitations or reservations in favor of the Timmons Radio Products Corporation which are included under the license heretofore granted the said corporation on Letters Patent 1,455,141; and Dubilier hereby authorizes the issuance of this particular license and authorizes the inventors to issue the same upon the conditions hereinbefore set forth.

The inventors hereby covenant and agree that before executing and delivering any of the aforementioned license agreements, they will submit the same to Dubilier for approval by it as to the form thereof and the terms thereof, and Dubilier agrees not to arbitrarily withhold such approval. Dubilier further agrees that it will not require the aforesaid licensees to agree to use Dubilier condensers, provided other consideration is given to Dubilier by way of additional royalties to be paid by the prospective licensees which, in Dubilier's judgment and opinion, is equivalent to the profits which it would have enjoyed upon the sale of such condensers to such

PLAINTIFF'S EXHIBIT No. 8—Continued

prospective licensees, but it is understood that in any event where any licensee does not use Dubilier condensers the inventors shall be entitled to fully one-half of the proceeds of such licenses, as hereinafter set forth.

Fourth. Since entering into the agreement of October 20, 1924, the following licenses have been granted, although none of these licenses includes any rights under Letters Patent 1,606,212:

Licensee	Date	Subject matter of license
Peerless Radio Corp	April 25, 1925	Lowell & Dunmore Patent 1,455,141.
Peerless Radio Corp., supplementary agreement B battery kits.	July 10, 1925	"
Argus Radio Corp	June 8, 1926	"
Fansteel Products Corp	July 15, 1926	"
Elkin Works, Inc	Sept. 15, 1926	Lowell & Dunmore Patent 1,455,141 & applications 2214 and 2215 and also Dubilier applications.
Philadelphia Storage Battery Co	Oct. 15, 1926	"
Willard Storage Battery Co	Jan. 17, 1927	"
Willard Storage Battery Co., addenda to agreement.	Feb. 8, 1927	"
Grigsby-Grunow-Hinds Co	Feb. 16, 1927	Lowell & Dunmore Patent 1,455,141 & applications 2214 and 2215.

Copies of all the licenses affecting the subject matter of this agreement are herewith attached and form a part hereof, and as provided in paragraph "First" hereof are not to be affected by this agreement.

Fifth. It is mutually understood and agreed that should any licensee under the said Patent No. 1,455,141 be sued, or threatened with suit under letters patent held by an adversary, that the inventors and Dubilier each shall have the independent right to grant a free nonexclusive license to such adversary in consideration of a similar license under said adversary's patent, or upon such other terms as the parties hereto mutually agree upon, it being expressly agreed, however, that each party shall keep the other fully informed in the matter and that each shall safeguard the other, the intent and purpose of the covenant being to provide that all licensees shall be maintained immune from damages arising out of any attack for infringement in so far as the inventors and Dubilier may be able to quiet said attack by licensing the adversary. Any sum or sums which shall be paid for effecting such settlement shall be divided one-half with the inventors and one-half with Dubilier.

Sixth. Subject to the licenses and rights already granted and reserved by the inventors as provided in paragraph "Third" hereof, the inventors hereby give and grant to Dubilier, its successors and assigns the exclusive right to manufacture, use, and sell and to grant

PLAINTIFF'S EXHIBIT No. 8—Continued

to others, upon such terms and conditions as in its uncontrolled judgment and discretion it may deem proper, the right to manufacture, use, and sell the aforesaid inventions as covered by both the aforesaid letters patents and applications for letters patent, and any other improvements of the same class invented or hereafter invented by said inventors, either solely or jointly, throughout the United States, its Territories, and dependencies, and covenant to grant to Dubilier or its nominee or nominees, the exclusive right to manufacture, use, and sell, and to grant to others the right to manufacture, use, and sell said inventions in each and every foreign country where said inventions may be covered by letters patent.

Seventh. The inventors, during the life of this agreement, agree to file and prosecute any reissue of any United States letters patent, as the said inventors and Dubilier may mutually agree are necessary and desirable to adequately protect the said inventions; and the inventors covenant and agree to keep Dubilier informed respecting all proceedings in the United States Patent Office in connection with any such reissue, interference or any other proceeding that may arise therein and to consult Dubilier before taking any action that may detrimentally affect its interest, and to submit to Dubilier for approval by it and/or its counsel, before filing the same, any and all papers respecting the said proceedings or any of them.

Eighth. Dubilier shall bear the expense of filing and prosecuting any further applications for letters patent upon the aforesaid inventions, modifications, and improvements, as it may elect to file in the United States or in foreign countries and the expense of maintenance of all letters patent that may be granted upon such applications, and hereby agrees to give to the inventors timely written notice as to all countries in which it elects to file additional applications for letters patent.

Ninth. The inventors shall execute all papers that may be necessary or desirable to enable Dubilier, or its nominee or nominees, to file and prosecute applications for letters patent in all countries in which Dubilier shall elect to secure patent protection for said invention, modifications, and improvements, and to prosecute all suits thereunder.

Tenth. In order to maintain this license, Dubilier covenants to pay to the inventors during the life of this agreement a royalty of five thousand dollars ($5,000), no more and no less, for any calendar year, payable two thousand five hundred dollars ($2,500) on the 30th day of July and two thousand five hundred dollars

PLAINTIFF'S EXHIBIT No. 8—Continued

($2,500) thereof on the 30th day of January in each year, said payments to be made by check payable to the inventors and delivered to them care of F. W. Dunmore, 3411 Rodman Street, Washington, D. C., which address shall be sufficient for all notices hereunder. In any year in which Dubilier fails to pay the full sum of five thousand dollars ($5,000) as herein provided, this license shall be automatically terminated, unless within sixty (60) days from the date that the inventors shall give written notice to Dubilier demanding payment of any deficiency in the amount of such royalty for the preceding year, Dubilier shall make payment of such deficiency; and it shall be the duty of the inventors to give such notice. Receipt is hereby acknowledged of payment in full of all sums due to the inventors up to and including December 31st, 1926, under the agreement of October 20, 1924, hereinbefore recited.

Eleventh. In addition to said royalty payment by Dubilier to the inventors paid for the continuation of this license, Dubilier covenants to pay to the inventors one-half of the royalty payments received from the licenses which may be granted by Dubilier under this agreement and similarly the inventors agree to pay to Dubilier one-half of the royalty which may be received from licenses hereafter granted by the inventors, including the licenses heretofore and herein reserved (except as modified by the following paragraph), but all licenses already granted shall be performed as written and executed.

It is understood and agreed, however, that Dubilier may waive its share of the royalties paid by any licensee, in consideration of said licensee agreeing to buy for the duration of the particular license electrical condensers from Dubilier in quantities and at prices satisfactory to Dubilier; and the inventors, in every such case shall not be entitled to share in the proceeds of the sale by Dubilier of such condensers. With respect to the reserved licenses herein described, Dubilier shall not be entitled to share the royalties payable to the inventors if the licensees shall either have agreed to buy electrical condensers from Dubilier or in lieu thereof pay additional royalty to Dubilier as heretofore in paragraph "Third" hereof provided.

Twelfth. Should this agreement be terminated for any cause whatsoever prior to the expiration of the patents mentioned, herein, Dubilier covenants and agrees to assign to the said inventors any and all outstanding licenses which may be granted hereunder and Dubilier shall not thereafter share in the amounts of royalties received by the inventor from such licenses, if any, after the date of said

PLAINTIFF'S EXHIBIT No. 8—Continued

assignment, except that Dubilier shall always be privileged to continue to enjoy the condenser business reserved to it in lieu of royalties as in any of said licenses provided.

Thirteenth. The term "device" as used in this agreement is understood to refer to and include the following:

(a) A device for supplying filament current to radio receiving sets, replacing the usual A battery.

(b) A device for supplying plate current to radio receiving sets, replacing the usual B battery.

(c) A combination device for supplying both A and B battery current for radio receiving sets.

(d) Apparatus comprising a loud speaker sound reproducer of the electrodynamic type operating from the lighting circuit.

(e) Apparatus constituting a power speaker for sound reproduction where the field circuit is supplied with rectified current.

(f) Any combination of two or more of these devices under (a) to (e).

Fourteenth. Dubilier and the inventors agree to require all licensees named to keep proper books of account with reference to all apparatus which they may manufacture and sell embodying the aforesaid inventions, and render periodic statements which shall be open to inspection by both Dubilier and the inventors, or their duly authorized agents, accompanied by payment of royalties shown to be due. Such statements shall be verified when necessary and may be checked at all reasonable times by an accountant designated by Dubilier and/or the inventors. Dubilier and the inventors agree to promptly exchange copies of all reports and statements received from licensees and keep each other informed of the progress of developments under the licenses.

Fifteenth. In order to formulate a method of procedure for payments under this agreement, the parties agree as follows:

(a) Dubilier or its nominee shall collect royalties due under all licenses granted by Dubilier or approved by Dubilier and signed by the inventors.

(b) Said royalties so collected shall be divided equally between Dubilier and the inventors and the proceeds promptly paid.

(c) Dubilier shall pay ten per cent (10%) of the amount received to the trust fund now on deposit at the Security Savings & Commercial Bank, 9th and G Streets, NW., Washington, D. C., account No. 43142 in the name of Percival D. Lowell, Francis W. Dunmore,

PLAINTIFF'S EXHIBIT No. 8—Continued

and John B. Brady, trustees. To these the name of the treasurer of Dubilier shall be added as a fourth trustee.

(d) The inventors shall pay ten per cent (10%) to the aforesaid trust fund of all amounts received from all licensees but the inventors shall not be required to pay any amounts to said trust fund arising from licenses granted to Timmons Radio Products Corporation or from the minimum annual sum payable by Dubilier in accordance with paragraph "tenth" hereof.

Sixteenth. The inventors and Dubilier mutually agree that the amounts paid into said trust fund shall be used within the discretion of the trustees in the payment of legal expenses incident to suits in which the inventors may join and for the protection of the patent situation relating to the inventions herein referred to. It is also mutually understood and agreed that when the said trust fund shall total the sum of five thousand dollars ($5,000) that payments into the same may be discontinued, to be resumed when necessary to reestablish the aforesaid amount. The trustees shall render an account and statement of said fund semiannually.

Seventeenth. The inventors hereby give and grant to Dubilier the right to sue in its own name and at its own expense any infringers of said patent or patents and to collect for its own use and behoof such damages and profits as may be assessed as the result of such suit or suits, provided, however, that in all cases where the inventors wish to join in any suit or suits they shall have the right so to do, in which event the expenses shall be paid out of said trust fund, and when such fund is insufficient, any additional amount required shall be paid in equal shares by the inventors and Dubilier; and the inventors shall then share equally in the division of all monies received, as damages or profits that may be collected.

Eighteenth. The inventors hereby specifically grant to Dubilier the right to grant sub-licenses to others under the aforesaid patents, and in every instance the inventors are to be furnished with a copy of any agreement for any inventions within the scope of this agreement. For the general protection and advancement of the patent situation, Dubilier agrees to consider the granting of licenses to others under the patents herein set forth whenever the inventors deem it beneficial so to do, and in any such case Dubilier agrees to act promptly on the application for such a license or the suggestion of the inventors with respect thereto.

PLAINTIFF'S EXHIBIT NO. 8—Continued

Nineteenth. If, as a result of court decisions, substantial protection for the main subject matter of this agreement is not afforded by said patents or if adversely held patents are declared to prevent manufacture of devices under said patents, Dubilier may terminate this agreement if it shall so elect and restore all rights hereunder to the inventors including an assignment of all the outstanding licenses.

Twentieth. In case of the termination of this agreement, for any cause whatsoever, all rights and obligations of the parties hereunder shall cease and their original rights of prosecution and defense of infringement suits shall be restored, except as stated in paragraph numbered twelve above.

Twenty-first. If any controversy shall arise between the parties as to the performance of any obligation under this agreement, the matter in controversy shall be submitted at the option of either party, to three arbitrators who shall have power to decide the matter in controversy, and to determine what, if any, amount shall be paid by either party to the other as liquidated damages for any breach of this agreement, and each party agrees to pay to the other any damages that may be assessed by the arbitrators. Upon such contingency either party may elect to arbitrate and shall notify the other party by registered mail. Within thirty days from the date of receipt of such notification both parties must appoint an arbitrator, and within sixty days after the date of such appointment both arbitrators must appoint a third arbitrator. If either party fails to appoint an arbitrator within the specified time, then the other party can apply to the American Arbitration Association to appoint for him the arbitrator, whom he must accept, and if both parties can not decide upon a third arbitrator within the specified time, then they may apply to the American Arbitration Association for the third arbitrator.

Twenty-second. This agreement is assignable and the agreement and the covenants herein contained shall be binding upon and inure to the benefit of the heirs, executors, administrators, successors, and assigns of the parties hereto.

Twenty-third. Dubilier agrees under this license not to enter into the manufacture of apparatus under the invention covered by Letters Patent 1,455,141, within an area of ten miles of Philadelphia, and agrees further not to grant licenses to others engaging in such manufacture in said area without the consent of the inventors, but this limitation and reservation shall not apply to articles manufactured under the invention covered by Letters Patent 1,606,212.

PLAINTIFF'S EXHIBIT No. 8—Continued

In witness whereof, Dubilier has caused these presents to be signed by its proper officer and its corporate seal to be hereunto affixed, and the inventors have hereunto set their hands and seals the day and year first above written.

DUBILIER CONDENSER CORPORATION,
[SEAL.] By (Sgd.) FRED D. WILLIAMS, *Pres.*
Attest:
W. J. SMITH, *Secretary.*
Witness: PERCIVAL D. LOWELL.
R. JORDAN.
Witness: FRANCIS W. DUNMORE.
CHAS. G. HUBBARD.

STATE OF NEW YORK,
County of Bronx, ss:

On this 12th day of May, 1927, personally appeared before me Fred D. Williams, to me known and known to me to be the president of the Dubilier Condenser Corporation of New York City, and he duly acknowledged to me that he executed the foregoing instrument on behalf of the said corporation, and that he was fully authorized to do so.

Witness my hand and notarial seal.

ARTHUR WILLIAMS, Jr.,
[SEAL.] *Notary Public* (*Stamp*).

STATE OF NEW YORK,
County of Queens, ss:

On this 16th day of May, 1927, personally appeared Percival D. Lowell, to me known and known to me to be the individual named in and executed the foregoing instrument, and he duly acknowledged to me that he executed the same of his own free will for the purpose therein set forth.

Witness my hand and notarial seal.

REYNOLD JORDAN,
[SEAL.] *Notary Public* (*Stamp*).

CITY OF WASHINGTON,
District of Columbia, ss:

On this 19th day of May, 1927, personally appeared Francis W. Dunmore, to me known and known to me to be the individual named in and who executed the foregoing instrument, and he duly acknowl-

PLAINTIFF'S EXHIBIT No. 8—Continued

edged to me that he executed the same for the purpose therein set forth.

Witness my hand and notarial seal.

CHARLES G. HUBBARD,
Notary Public, D. C. (*Stamp*).

[SEAL.]

PLAINTIFF'S EXHIBIT No. 9

License agreement relating to Patent No. 1,635,117 granted to Dubilier Condenser Corporation by Francis W. Dunmore

AGREEMENT

This agreement executed this 15th day of July, 1927, by and between Dubilier Condenser Corporation, a corporation of the State of Delaware, having an office and place of business at 4377 Bronx Boulevard, New York City, and Francis W. Dunmore, of Washington, District of Columbia.

Witnesseth, that whereas Francis W. Dunmore did on February 27, 1922, file application for letters patent of the United States on improvements in relays, Serial Number 539,591, and has obtained thereon Letters Patent No. 1,635,117, dated July 5, 1927; and

Whereas on July 13, 1922, the said Francis W. Dunmore entered into a license agreement, as per the attached copy, with Morkrum Company of Chicago, Illinois, covering the use of his invention in connection with printing telegraph and other electrical apparatus; and

Whereas the invention as covered by said letters patent is also susceptible of use in radio broadcast entertainment receivers and particularly in electron tube apparatus as covered by Lowell and Dunmore Patents No. 1,455,141, dated May 15, 1923, and No. 1,606,-212, dated November 9, 1926, which form the subject matter of an agreement between said Dunmore and his coinventor, said Lowell, and said Dubilier Condenser Corporation, dated May 19, 1927.

Now, therefore, to all whom it may concern, be it known that for and in consideration of one dollar ($1.00) by each party to the other in hand paid and the mutual provisions and covenants hereinafter set forth, the parties hereto have agreed and do agree as follows:

1. The parties to this instrument hereby state and declare that said Patent 1,635,117 is embraced by said agreement of May 19, 1927, but only so far as it may cover radio-telephone broadcast receiving apparatus and not with respect to its use as a remote control device or apparatus for operation of relay mechanism, and said Patent

PLAINTIFF'S EXHIBIT No. 9—Continued

No. 1,635,117, is now hereby expressly included within said agreement, on the same terms, reservations, provisions, and conditions, and no more, stated in said agreement as affecting the aforesaid Patent No. 1,606,212, and said Dunmore hereby retains for his own sole use and benefit, in connection with said Patent No. 1,635,117, reservations, limitations, and privileges of the same scope, nature, force, and effect as those retained by Francis W. Dunmore and Percival D. Lowell jointly under said agreement with respect to Letters Patent 1,606,212. It is further understood and agreed that Francis W. Dunmore reserves to himself the exclusive right to grant licenses, collect royalties, and otherwise personally enjoy for himself, his heirs, his legal representatives, and his assigns all the benefits of the invention covered by said Letters Patent No. 1,635,117, wherever said invention is used for the control of a remote control device or apparatus for operation of relay mechanism for effecting the opening and closing of an electrical circuit, but the rights so reserved by said Dunmore shall not in any manner extend to the manufacture, use, or sale of the invention as a rectifier or battery substitute for utilization in radio telephone broadcast receiving apparatus.

2. Dubilier Condenser Corporation agrees that in all licenses which may hereafter be granted under said Letters Patent 1,635,117 for radio telephone broadcast receiving apparatus, either singly or in conjunction with Patents 1,455,141 and 1,606,212, the following clause must be included:

"This license does not extend to licensee any rights under Letters Patent 1,635,117 to make, use, or sell the invention of this patent as a circuit maker and breaker, such as for an electrical relay."

In witness whereof the said Dubilier Condenser Corporation has caused this agreement to be signed by its president and its corporate seal to be hereunto affixed, and the said Francis W. Dunmore has hereunto set his hand and seal the day and year first above written.

DUBILIER CONDENSER CORPORATION,

Attes: By (Sgd.) FRED D. WILLIAMS, *President.*

(Sgd.) W. J. SMITH, *Secretary.*

(Sgd.) FRANCIS W. DUNMORE.

Witness:

(Sgd.) JOHN B. BRADY.

STATE OF NEW YORK,

County of Bronx, ss.:

On this 22nd day of July, 1927, personally appeared before me Fred D. Williams, to me known and known to me to be the president of the Dubilier Condenser Corporation of New York City, and he duly acknowledged to me that he executed the foregoing instrument

FOLDOUT(S) IS/ARE TOO LARGE TO BE FILMED

PLAINTIFF'S EXHIBIT No. 9—Continued

on behalf of the said corporation, and that he was fully authorized to do so.

Witness my hand and notarial seal.

(Sgd.) ANDREW A. MILLER.

[SEAL.] (*Stamp*)

CITY OF WASHINGTON,

District of Columbia, ss.:

On this 15th day of July, 1927, personally appeared Francis W. Dunmore, to me known and known to me to be the individual named in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same for the purpose therein set forth.

Witness my hand and notarial seal.

(Sgd.) ELLEN G. McCARTHY,
Notary Public, D. C.

[SEAL.] (*Stamp*)

PLAINTIFF'S EXHIBIT No. 10

Organization chart of the Bureau of Standards

(See paster facing this page.)

PLAINTIFF'S EXHIBIT No. 11

LEW:AN
I–6

RADIO LABORATORY,
BUREAU OF STANDARDS,
July 29, 1921.

Radio laboratory outline
Chief of section, J. H. Dellinger
Alternate chief, L. E. Whittemore

Airplane Radio	F. W. Dunmore.
Project No. 37	J. L. Bernard, C. T. Zahn.
Project No. 39	(F. W. Dunmore.)
Project No. 40	J. A. Willoughby, F. H. Engel.
Project No. 42	P. D. Lowell.
Direction finding	(F. W. Dunmore), F. M. Baer.
Electron tubes	L. M. Hull.
Project No. 41	J. A. Rodman.
Project No. 39	H. A. Snow.
Antennas: (Project No. 40)	*C. S. Ballantine.
Radio Transmission (Project No. 41)	S. Kruse. M. S. Strock.

PLAINTIFF'S EXHIBIT No. 11—Continued

Radio design and insulating materials	J. L. Preston, E. L. Hall.
Radio receiving sets	(J. L. Preston), (E. L. Hall), N. Snyder, H. A. Wheeler, *H. F. Harmon, *E. Schrepfer.
Radio measurements and testing	R. T. Cox, H. B. Daniel, H. T. Given.
Publication	R. S. Ould, J. P. Buckley, C. E. Zandonini.
Office	A. Noel, M. Harlow, M. W. Barksdale, T. Hines.
Laboratory equipment	(J. L. Preston), (H. B. Daniel), E. B. Shea, G. Rheinbold, J. R. McArtor.

* Not yet reported for duty.

PLAINTIFF'S EXHIBIT No. 12

LEW:MH
I–6

RADIO LABORATORY,
BUREAU OF STANDARDS,
October 3, 1921.

Radio laboratory outline
Chief of section, J. H. Dellinger
Alternate chief, L. E. Whittemore

Airplane radio:	
Project No. 42	F. W. Dunmore.
Project Nos. 37 and 40	F. H. Engel.
Direction finding	(F. W. Dunmore.)
Electron tubes:	
Project No. 38	H. A. Snow.
Radio transmission:	
(Project No. 41)	S. Kruse, J. A. Willoughby, M. S. Strock.
Radio design and insulating materials	J. L. Preston, E. L. Hall.
Radio receiving sets	(J. L. Preston), (E. L. Hall), H. A. Wheeler, H. F. Harmon, M. S. Hitchcock.

PLAINTIFF'S EXHIBIT No. 12—Continued

Radio measurements and testing	R. T. Cox, N. Snyder, P. D. Lowell, H. T. Given.
Publication	R. S. Ould, J. P. Buckley, C. E. Zandonini.
Office	A. Noel, M. Harlow, M. W. Barksdale, T. Hines.
Laboratory equipment	(J. L. Preston), A. H. Simmons, G. Rheinbold, J. R. McArtor.

PLAINTIFF'S EXHIBIT No. 13

JHD:MWB
I–6a
73:55–h

RADIO LABORATORY,
BUREAU OF STANDARDS,
July 16, 1920.

INFORMATION FOR MEMBERS OF THE RADIO LABORATORY

1. Laboratory organization.
2. Laboratory hours and personal matters.
3. Periodic reports.
4. Equipment.
5. Preparation of official letters and technical reports.
6. Meetings.
7. Technical information and education.

1. Laboratory organization

Division I of the Bureau of Standards, the electrical division, is divided into thirteen sections, all of which are located in the east building except the radio communication section.

Radio laboratories located at the bureau.—The Bureau of Standards radio laboratory occupies the upper floor of the radio building. The lower floor is occupied by two organizations independent of the Bureau of Standards, the naval radio research laboratory and the Signal Corps research laboratory. Further particulars are given in the "Guide to Radio Laboratory" (Report 48–b–2, copies available from the radio office, room 207).

Organization of groups.—A list of the persons in the section is posted in room 207, arranged according to the groups into which the

PLAINTIFF'S EXHIBIT No. 13—Continued

work is divided. Members of the laboratory report to the group chief whose name appears at the head of the group in which the member is placed.

Questions of procedure.—For matters of procedure not covered in these instructions, consult the group chief. Such matters are covered in part by a set of memoranda on procedure which each group chief has, and which may be consulted by any member of his group.

2. Laboratory hours and personal matters

Hours of work.—The official hours of work for all employees, except those mentioned below, are from 9:00 to 4:30, with one-half hour for lunch, except that on Saturdays between the middle of June and middle of September the hours are from 9:00 to 1:00. It should be a matter of pride with members of the laboratory to be actually at work at all time within the official hours. This applies particularly to the minutes just after 9:00 a. m.

All apprentices (except shop apprentices), laboratory helpers, junior laboratory helpers, telephone operators, elevator boys, and others specially designated, start work at 8:30. Lunch and closing time are the same as for other employees.

Construction force, including mechanicians, toolmakers, machinists, shop apprentices, etc., start work at 8:00. Such employees stop work at 12:30 on Saturday afternoon; otherwise, lunch and closing time are the same as for other employees.

Time cards.—All employees receiving a basic salary of $1,440 and under are required to turn in time cards. Time cards will be furnished to the employee. The time of arrival and departure being entered in the proper column each day, and at the end of each month (minor assistants mentioned below at the end of each week), the card must be turned in promptly to the group chief. All apprentices, junior laboratory helpers, telephone operators, elevator boys, and others specially designated are to turn in weekly time cards.

Leave.—Whenever an employee desires to be absent during official hours, he should fill out a leave slip, obtainable from the office, room 207. When a person has been absent on account of illness, he should fill out a sick leave slip as soon as he returns to work. The leave slip must always be submitted to the group chief, and his approval secured before leave (except sick leave) is taken. It is preferable that this be done at least a day in advance. Vacations, involving absence of one or more weeks, should be arranged for with the group chief as far in advance as possible. A vacation

PLAINTIFF'S EXHIBIT No. 13—Continued

chart, posted in the office, room 207, shows what absences of this sort have been arranged for.

Temporary employees are not allowed leave with pay, nor will such leave accrue, during the first month of service. Beginning with the second month of service they may be allowed leave and then only accrued leave at the rate of 2½ days per month.

During the first year, permanent employees are allowed accrued leave at the rate of 2½ days per month, provided the work permits. The accrued leave for any year can not be allowed after the end of that calendar year. After the first year's service, unaccrued leave may be granted, but in case the employee leaves the service before the leave has accrued, it will be necessary for the employee to refund the pay for any excess leave.

The number of days of annual leave allowed is exclusive of Sundays and legal holidays. Sundays and legal holidays, however, occurring within a period of sick leave or leave without pay, will be counted in the number of days of leave.

The minimum amount of annual leave is a quarter hour, minimum leave without pay is 1 hour, and minimum sick leave is one-half day.

Lunches.—The bureau allows one-half hour for lunch. Food is not to be used in the laboratory at other times. Persons who bring their lunches should take extreme care that no particles of food remain about the rooms. Remnants should be put into special metal cans provided by the bureau or else in toilet-room waste baskets; never in other waste baskets.

Tobacco.—The use of tobacco during official hours of work is not approved.

Personal work.—Whenever a person wishes to work in the laboratory for unofficial purposes, the approval of his superior officer should first be secured. Such work should not be done on official time. No consumable supplies should be used nor should any Bureau of Standards property be used up in such work.

Use of laboratory outside of official hours.—Anyone who expects to be in the laboratory beyond the official hours, either for personal or official business, should inform his group chief. To secure entrance to the bureau grounds outside of official hours, members must show passes which bear permission to do overtime work, signed by the division chief.

For the use of the shop outside of official hours, see rules posted in shop and in radio office, room 207.

Use of bureau telephones.—Connections outside the bureau may be made over the telephones in rooms 207, 206, 205, 201, 214, and 210.

PLAINTIFF'S EXHIBIT No. 13—Continued

The bureau allows members to use these telephones for necessary personal calls, at the rate of two cents a call. When calling, say "Outside: personal call for ———," giving your name. Record of these calls is kept at the telephone switchboard, and the bills collected once each month.

If expecting telephone calls, be sure to give your correct branch number, as otherwise the bureau switchboard operator is not always able to make prompt connection.

There are regular pay telephones in the hall of the south building, basement of the west building, second floor of the north building, and first floor of the industrial building.

Buzzers.—A buzzer system is used for requesting the presence of members in the offices, rooms 205 and 206, for consultation. Your call letter is . The call is usually followed by a signal indicating the person calling; these signals are:

– Dr. Dellinger, room 206.

– – Mr. Whittemore, room 206.

Address and home telephone number.—Each new member should give his address and telephone number to the office, room 207, as soon as he becomes located. The office should also be kept informed of all changes.

Rooms and board.—A file of information on available accommodations is kept in room 207. All members of the laboratory are requested to cooperate in making this of value by contributing such information. A more extensive list is kept by the personnel section, room 308, south building.

Bulletin board.—Notices to be posted on the bulletin board should be handed to clerk in charge of the radio office with necessary explanations and details.

3. Periodic reports

Weekly report cards.—It is the practice of this laboratory to require monthly and weekly reports from its members. The weekly reports are written on 5 × 8 cards. Entries should be made on the card each day, stating what work was done. The card should bear the dates of the days included, the year, the name of the writer, and should be put into the files Saturday afternoon, at the close of the week's work.

Monthly reports.—The monthly reports present a summary of the work, written with the aid of the weekly report cards. These monthly reports are used by the section chief in writing the monthly report of the section. They should be concise and accurate. They

PLAINTIFF'S EXHIBIT No. 13—Continued

may be written in pencil to be handed in at the office, room 207, for typing. Three copies of these reports are made, one for the division office, one to be filed in 207 with all other reports of members for the current month, and the other to be filed in 207 in the members' personal folders. These reports are due on the last day of the month.

4. Equipment

Care of building.—Every effort should be made to keep the laboratory in good condition, and each member should assume a personal responsibility in this matter. The last person to leave a room in the afternoon should lock the door; special emphasis is laid on the requirement that all windows are to be locked also. Whenever a room is left vacant, at lunch time or any time during the day, the door should be locked. Each person is provided with a key to the room to which he is assigned, and is responsible for the care of the apparatus in that room.

Supplies.—Laboratory supplies may be obtained from the stockroom 201, upon presentation of slip initialed by group chief. Desk supplies are issued from 207 upon oral request.

It should be unnecessary to urge care and economy in the use of all supplies.

Apparatus.—All laboratory apparatus not needed further for immediate use should be returned to the stockroom. Conscientious attention to this will make more equipment available to the entire laboratory than would otherwise be possible.

No equipment is to be taken from any room without permission of the group chief or other person in charge of the room. This applies to tools and other material as well as to measuring apparatus.

No equipment is to be taken from the bureau grounds without the knowledge of the section chief.

The bureau has suffered considerably from theft, and it is very important that members cooperate in discovering, intercepting, and reporting losses.

Switchboards.—A copy of the rules governing the use of the switchboards is kept available in room 207, and must be carefully read by each member of the laboratory. On account of the danger to life, no person who has not read these rules is authorized to touch any switchboard.

Storage batteries.—Each member of the laboratory is expected to familiarize himself with the care of storage batteries. A number of publications giving information on the care, operation, and charging of storage batteries are available for consultation at the stock-

PLAINTIFF'S EXHIBIT No. 13—Continued

room. Mr. Daniel, who has general supervision of the storage batteries, may be called upon for assistance when special difficulty is experienced.

5. Preparation of official letters and technical reports

Routine.—The group chief should be consulted for the form and procedure to be followed.

Terminology, language, etc.—Members of the laboratory should use the standard terminology, abbrevations, and symbols adopted by the laboratory. These are contained in reports 78–a and 78–b. A copy of each can be secured from the radio office, room 207. For suggestions on rhetorical and editorial matters, and information on approved style, see report 87–a.

The international electric units, based on the ohm, ampere, centimeter and second, should be used; information is given in Circular 60 and Scientific Paper 292.

6. Meetings

Signal for meetings.—The meetings which the scientific staff of the radio laboratory should attend are announced by three rings of the hall bell.

Scientific staff meetings.—Every Friday during the winter months, at 3.30 p. m., meetings are held for all members of the scientific staff of the bureau. Attendance is optional, subject to approval of group chief.

Electrical division meetings.—On alternate Tuesdays during the winter months, meetings of the electrical division are held, at which the work of the various sections of the division is presented. Attendance is required unless approval of absence is given by the section chief.

Interlaboratory staff conferences.—On the third Thursday of each month the members of the scientific staff of all radio laboratories located at the bureau meet to discuss subjects which are chosen by a committee from these laboratories. The meetings are held at 3.30 p. m., and members are expected to attend and to participate in discussion.

Radio staff conferences.—At these informal conferences, held at 3.30 p. m., all members of the scientific staff are expected to be present and to participate in discussion.

7. Technical information and education

Education.—All members of the laboratory are urged to continue their technical training. College courses in physics and mathematics

PLAINTIFF'S EXHIBIT No. 13—Continued

and other subjects are given at George Washington University in the late afternoon and evening. Lecture courses of graduate grade are given at the bureau. Credit toward advanced degrees can be secured from universities for the successful completion of these courses.

Members should familiarize themselves with the contents of the "Principles Underlying Radio Communication" and Circular 74, "Radio Instruments and Measurements." A copy of each may be secured from Mr. Ould, and in addition, Report 79–a, "Radio Publications of the Bureau of Standards" and Circular 24, "Publications of the Bureau of Standards." Copies of any publications of the bureau may be obtained from the publication clerk, 308 south building.

Much valuable material for study along radio lines is included in the various files and other sources mentioned below.

Electrical measurements.—The following references and textbooks on electrical measurements other than radio-frequency measurements may be consulted either in the radio library or the bureau library.

Electric and Magnetic Measurements. Charles M. Smith. (Macmillan) 1917.

Principles of Electrical Measurements. Arthur W. Smith. (McGraw-Hill) 1914.

Electrical Measurements. F. A. Laws. (McGraw-Hill) 1917.

Electrical Measurements. D. P. Moreton.

Electrical Instruments and Testing. Norman H. Schneider. (Spon & Chamberlain.)

Meter Testing and Electrical Measurements. O. J. Bushnell and A. G. Turnbull.

Elementary Treatise on Electricity and Magnetism. Foster and Porter. (Longmans, Green & Co.) 1913.

Magnetism and Electricity for Students. H. E. Hadley. (Macmillan.)

Practical Alternating Currents and Alternating Current Testing. C. F. Smith. (Scientific Publishing Co.) 1918.

Electricity and Magnetism for Students. S. G. Starling. (Longmans, Green & Co.) 1918.

Absolute Measurements in Electricity and Magnetism. Andrew Gray. (Macmillan) 1893.

Electrical Instruments. Murdoch and Oschwald. (Whittaker & Co.) 1915.

Industrial Electrical Measuring Instruments. K. Edgcumbe. (Constable & Co.), Second edition. 1918.

PLAINTIFF'S EXHIBIT No. 13—Continued

Electrical Meters. C. M. Jansky. (McGraw-Hill.)

An Elementary Book on Electricity and Magnetism. D. C. Jackson. (Macmillan) 1919. Revised and enlarged by N. Henry Black.

Electrical Measurements in Practice. F. M. Farmer. (McGraw-Hill.)

A Handbook of Electrical Testing. H. R. Kempe. (E. & F. Spon, Ltd.)

Electrical Measurements. Carhart & Patterson. (Allyn & Bacon.)

Bureau of Standards Circulars Nos. 6, 20, 31, 36, 79.

A very elementary treatment, suitable for persons with no previous knowledge of electrical measurements, is given in the Weston Company booklet entitled "Elementary Electrical Testing and Practical Measuring Apparatus" in catalog file in room 207.

The following reports in the general information file, room 207, may be consulted by members of the laboratory and will be found useful for general study of these subjects:

69k—Electrical measuring instruments.
69j—Alternating-current wave form.
69i—Low-frequency measurement of capacity and inductance.
69h—Magnetic measurements.
69g—Resistance and other electrical properties of conductors.
69l—Current-carrying capacity of wires and cables.
69m—Electrical and thermal properties of insulating materials.

Precision and expression of results of measurement.—It is important that all members of the laboratory understand and practice the principles of precision of measurement.

Calculations should be made with one significant figure more than the experimental data, and final calculated results should in general be expressed to the same number of significant figures as the the experimental data. These two rules are, respectively, to avoid the enlargement of the fractional error in the course of the calculation, and to prevent misjudgment of the precision of the data by one who inspects the results.

The difference between accuracy and precision of measurement should be understood.

The proper methods of rounding off numbers should be followed. When, in rounding off a number, the figure to be dropped is a 5, the number should be rounded off to the nearest even figure in the last place retained.

Instruction on the principles is obtainable from the following:

"Laboratory Course in Physical Measurements," Sabine—Significant Figures, Appendix I; curve plotting, Appendix II.

PLAINTIFF'S EXHIBIT No. 13—Continued

"Experiments in Physics," Ives—pp. xiii, xiv.

"Physical Measurements," Kohlrausch—

(1) Errors of observation, mean and probable error, p. 1.
(2) Influence of errors of observation on the result, p. 4.
(3) Determination of empirical constants by the method of least squares, p. 11.
(4) Corrections and calculation of corrections, p. 24.
(5) Interpolation, p. 27.
(6) Rules for numerical calculation, p. 28.

"Laboratory Manual of Physics and Applied Electricity," Nichols—

(1) Observations, pp. 3, 4, 5.
(2) Sources of error, pp. 13, 14.
(3) Probable error, p. 15.
(4) Influence of errors of observation upon derived results, pp. 18–20.
(5) Determination of constants by the method of least squares, pp. 21–25.

Instruction in the use of the slide rule may be obtained from the Mannheim complete manual, in Catalog File No. 51, radio office.

When numerical results are given out to the public, as in test certificates and reports, they should in general be rounded off to a lower order of precision than the certain accuracy of the measurement. When a statement of the probable accuracy is given, it should always be conservative. This is necessary because the Bureau of Standards must be doubly certain of all results it gives out.

The group chief should be consulted for further instruction in the subject of precision and expression of result of measurement.

Sources of technical information on the subjects of this laboratory.—Besides the sources mentioned above, members of the laboratory have available the information contained in the files and other sources listed below.

In main hall

Library.—Containing small collection of books, pamphlets, periodicals, and file of Science Abstracts. Miss Barksdale should be asked for anything wanted from the library, and a charge slip must be left for anything withdrawn. Consult bureau library, third floor of south building, for books on subjects not covered in radio library. Suggestions for additions to the radio library should be made to Mr. Ould.

Table display of publications, laboratory reports, photographs, and radio drawings. These may be consulted at any time, but under no circumstances are they to be carried away. Copies of the publi-

PLAINTIFF'S EXHIBIT No. 13—Continued

cations may be obtained from the publication clerk, 318 south building, and copies of the laboratory reports may be obtained from the radio office, room 207. Each of the black folders of laboratory reports contains an index of the reports on the general subject covered by the reports in that folder.

In room 201

(Mr. Ould should be consulted for any of the material in this room.)

Reference file.—A card index to periodical radio literature (containing 7,500 cards, July, 1920). Twice each month a typewritten list of new references is supplied to the chief of each group except the office group; the list is brought to the attention of each member of the group. Important articles which do not get into these reference lists should be brought to the attention of Mr. Ould.

Radio patents.—Copies of radio patent specifications are received weekly as issued by the Patent Office.

In radio office, room 207

(When it is desired to consult any of this material, the clerk on duty should be asked for it. In all cases, except the blue-printed duplicates of laboratory reports, a sheet of pink paper upon which is noted the number or distinguishing description of the material borrowed, the name of the person, and the date, is inserted in the file as a record of the material. Anything borrowed from the office files should be returned as promptly as possible.)

Laboratory reports.—Duplicate copies of any of the blue-printed laboratory reports shown on the table in the main hall may be obtained from the office when actually needed for work or study, and become the property of the individual. Copies are not available in sufficient numbers to permit individuals to acquire a set or file of these. An effort is made to bring out the material in these reports in printed form later.

General information file.—There is a card index to this file, in small drawers above the drawers which hold the reports. This file contains reports and technical information of great variety.

Laboratory data.—Memoranda, results of laboratory work, and data of all kinds are filed for reference in the drawer marked "Apparatus constants data." The material is filed by subject.

Catalogs.—Indexed by firm name and by subject. Supplemented by list of manufacturers arranged by subject.

Test certificates and reports.—Copies for reference, and, in some cases, duplicates, may be obtained from this file.

PLAINTIFF'S EXHIBIT No. 13—Continued

Index of radio drawings.—Arranged by subject.

Correspondence.—There are a name index and subject index of correspondence.

Periodic reports.—The file includes the monthly reports of individuals and the sections, and the semi-annual reports of the sections.

Reports of meetings.—Interlaboratory staff conferences (book). B. S. radio staff conferences (book). Miscellaneous meetings (file 74).

Technical news bulletin.—A monthly bulletin, giving news on the progress of various lines of work, is issued by the bureau. It is in mimeographed form, and is sent out to newspapers. A copy is on file in the general information file in the radio office, room 207, in file 84. By reading this bulletin, one can keep in touch with the current activities of the bureau. Information about the past work of the bureau as a whole is given in the director's annual report, available for consultation in the radio library.

Subject classification.—A uniform classification of radio subjects has been developed. A copy of the classification system may be obtained from the radio office as report 79. The reference file, laboratory data, etc., are arranged according to this system.

(Sgd.) J. H. DELLINGER,
Chief, Section 6.

WASHINGTON, D. C.

JHD:MB:IEB
I–6a

PLAINTIFF'S EXHIBIT No. 14

RADIO LABORATORY,
BUREAU OF STANDARDS,
February 26, 1920.

May be published only after specific permission by Bureau of Standards

Preparation of papers

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7. Capitalization.
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1. Footnotes.
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3. Tables.
4. Abbreviations.
5. Mathematical symbols and equations.
6. Proof reader's marks in manuscript.
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V. Miscellaneous topics.
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I. INTRODUCTION

The first essential is that the work which the paper is to describe has been well and carefully done, and that it has led to some definite result. While it is impossible to make every paper complete, no points bearing on the validity of the conclusions should be left in doubt. Correctness of statements and conclusions is necessary.

Careful attention should be given to the preparation of papers presented for publication, and an effort should be made to make them as clear and interesting as possible. It is not merely a question as to whether the paper is accurate and clear to the author and the editorial readers, but it is important that it be clear to the body of readers for whom it is intended. In some cases a very technical treatment is proper. But in many cases the paper will be intended for a class of readers that requires a popular treatment and considerable explanation. This is particularly true of circulars. On the other hand, too great length and too much detail should be avoided.

Authors should bear in mind that the success of their papers depends on the form and presentation of the paper as well as on

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the scientific material that it contains. The printed page will show faults in the arrangement of material that are easily overlooked in the manuscript or typewritten copy.

II. ESSENTIAL PARTS OF A PAPER

The essential parts of a paper are title, outline, principal subdivisions with their subordinate headings, the appendixes (if required) and the illustrations.

1. Title

The title of a paper should be brief and descriptive. It is often best not to decide on the exact wording of the title until the paper is finished. Compound titles should be avoided when possible, unless an important section may thereby be overlooked. In any case the author should carefully consider whether the title indicates the subject matter of the paper.

2. Outline

Every paper except brief notes should be preceded by "contents" which indicates the main divisions and the principal subdivisions. In the preparation of a paper a tentative outline is very useful and should be made in practically all cases to insure a well balanced presentation of the material.

3. Principal divisions

It is not possible to give any list of the principal divisions of a paper that shall be generally applicable, but in the following paragraphs the character of the various principal divisions more or less common to all papers is indicated. However, not every paper need have all these parts, and indeed, short papers should have only a few of them and these not necessarily under separate headings. The number of principal divisions for the majority of papers should not exceed ten. A principal division may be subdivided into subordinate parts of different orders when the material is of such a character as to require it. Proper subdivision of a paper is of great importance but excessive subdivision of a paper is confusing to the reader. The order of a subdivision is indicated by the type of its heading and by numbers or letters. A subdivision of a larger heading implies that the larger heading consists of several coordinate parts. It is not proper, therefore, to place a single subordinate heading under one of higher order. The headings in the text

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should correspond exactly with the outline which stands at the beginning of the paper and serves as a table of contents.

Introduction.—The primary purpose of an introduction is to acquaint the reader with the subject matter of the paper and to give him such information as may be necessary to properly understand what follows. The reason or occasion for doing the work should be indicated. Experimental papers should also have a very brief outline of the method and a succinct statement of the results. The introduction should arouse the interest of the reader and enable him to follow the details of the paper with the least expenditure of effort.

Historical reviews.—Some papers call for a historical review, but most do not. A historical discussion or review of the previous literature should be confined to papers which have a direct and important bearing on the work described. It is desirable that the author be familiar with the literature of the subject, but he should select from the papers which he has consulted only those that have an immediate bearing on the subject. The choice of other principal divisions will depend upon the character of the paper, and, like the detailed writing, must be left to the author. The following notes may, however, be of some service.

Description of apparatus.—The author should bear in mind that the description of his apparatus should convey a mental picture to the reader. It is more important to give a description of the general character of the apparatus and the principle on which it works than to give minute details which can only be grasped after the main principles are understood.

Description of experimental procedure.—The experimental procedure, if it be described, should represent the best procedure learned from the experiments with only such references to the unsuccessful trials, as may be of unusual interest. In no case should the laboratory note book be transcribed into the paper except as the material that it contains has been classified and digested so that the reader may obtain the valuable part without burdensome details.

Discussion of results.—The discussion of the results should include, (a) an analysis of the sources of error which are present in the work and the precautions taken; (b) a condensed statement of the net results; (c) the conclusions drawn from the result; (d) the applications of the result. If the reasons are given why the result is believed to be superior (if it is) to previous work on the same subject, it should be done carefully and without unnecessarily disparaging the work of others.

Conclusions and summary.—Authors should never confuse the conclusion and the summary. Ordinarily the conclusions will be

PLAINTIFF'S EXHIBIT NO. 14—Continued

part of the discussion of results, since the conclusions are the deductions drawn from the experimental data. Only long papers should have a conclusion as a separate heading. The summary consists of short terse paragraphs, preferably numbered, each of which states some fact developed in the paper. The summary should never contain anything which has not been brought out in the previous part of the paper. Every paper, except when very short, should have a summary. Especial care is necessary in preparing the summary (as is also true of the introduction) because a vast majority of readers look at the introduction and summary first and decide from the impression obtained whether they think the paper worth reading as a whole.

4. Appendixes

As a general rule a bureau paper will not require an appendix. Some of the material which may properly be put into an appendix are bibliographies, tables, and other data for use in computations, extended proofs of a mathematical character which would be out of place in the body of a paper, or material which, while related to the subject matter of the paper could also be published independently.

The preparation of a bibliography is a difficult and time consuming work, and the number of instances in which the publication is desirable is relatively small. Before preparing a bibliography for publication the author should assure himself that the project meets the approval of others in the bureau who are familiar with the subject and will be acceptable to the editorial committee.

5. Illustrations

Bureau publications are illustrated with halftone plates and zinc etchings. Halftone plates are made chiefly from photographs, and titles being set separately in type. Objects on photographs may be designated by letters or numbers which can either be put on the object at the time the picture is made, or subsequently put on the prints. Names of objects shown on a halftone may also be printed under the plate if this is desired. Zinc etchings are used to reproduce line drawings, curves, and other illustrations involving only solid black and white. Zinc etching is a photographic process, consequently the figure will appear as drawn, including lettering, numbering, etc. Curves should be drawn on actinic blue coordinate paper; and the coordinates which are to appear must be ruled in with black india ink. The blue lines do not appear in the reproduction. The titles of the figures are set up separately in type. In preparing copy for figures it is worth remembering that while the engraver may be

PLAINTIFF'S EXHIBIT No. 14—Continued

able to remove something from a zinc plate it is impossible for him to add anything.

Illustrations with figure, numbers, and descriptive titles should usually accompany the paper. Large drawings or photographs that might be damaged by handling may be retained by the author, subject to the inspection of the editorial committee. In this case substitute illustrations should accompany the paper. The curves and drawings should be neatly prepared and lettered in bold round letters so that they may be photographically reproduced. This usually involves a considerable reduction in size which may lead to unsatisfactory results if the author has not carefully considered the effect of the reduction on each part of the illustration. The lettering may become illegible if it is not sufficiently large in the original, fine lines may disappear and dotted lines may appear continuous. In dotted lines the space between the dots should be equal to or greater than the diameter of the dots, if these are small. It has been found by experience that when the reduction is in the ratio 5:1 (linear dimensions) dots on millimeter centers will not be resolved or will be too small to be distinct when reproduced by the zinc etching process now used for the bureau's publications. The following data about the first illustration in Scientific Paper No. 283 are given as a rough guide for authors preparing illustrations requiring considerable reduction in size.

Ratio of reduction 4:1 (linear dimensions).
Height of lettering (maximum) for " Ratio of " etc., 8 mm.
Thickness of lines of letters, 1 mm.
Diameter of circles and dots, 3.5 mm.
Thickness of line for the three curves, 1 mm.

6. Abstracts

Two kinds of abstracts are required. The editorial record sheet (Form No. 114) requires an abstract of 125 words or less. This abstract is used in the descriptive list of the bureau's publications (Circular 24) and therefore reaches a very great number of readers. For this reason it should be prepared with special care. It should state in so far as possible: (a) the object of the work; (b) the result found; (c) the conclusion drawn from the result; and (d) the applications of the result.

A longer abstract of one to several typewritten pages is required by the office for the use of the Journal of the Washington Academy of Sciences, the Journal of the Franklin Institute and other similar publications. This abstract should cover the points mentioned above

PLAINTIFF'S EXHIBIT No. 14—Continued

with sufficient detail to make the results of service to the reader without the necessity of referring to the detailed paper. Two copies of this abstract should accompany the paper. The author's name is shown on this abstract except in the case of circulars.

III. SUGGESTIONS ON RHETORICAL MATTERS

1. Sentence structure

The ability to arrange words properly in sentences that will convey clearly and forcibly the ideas to be expressed is the first essential in good writing. The position of words in the sentence indicates their relative importance, the positions of emphasis being at the beginning and end of the sentence. Unnecessary words and involved abverbial clauses often crowd the important words from their rightful places so that the author's meaning is obscured or lost. This subject can not be treated in detail here, for no amount of exposition can take the place of the care that should be exercised by authors of papers.

2. Paragraphing

Every paragraph should be a subdivision of a larger heading and treat some definite part of the subject of the given section.

The paragraph is a unit in which each sentence contributed its part to the fundamental idea of the paragraph. The subject of the paragraph is often expressed in one of the sentences, but if not it should be possible to paraphrase the main idea in a single sentence. The length of the paragraph will vary with the importance and range of the subject, but the best writers seldom exceed three hundred words nor use less than what may properly constitute three or four sentences. When the printed page is without one paragraph-indentation the effect is fatiguing to the reader; but a succession of short paragraphs, except in the summary, generally indicates a lack of proper continuity of thought. It is worth while to consider carefully the form and structure of each paragraph, because the common fault of including extraneous matter, which should be made into a separate paragraph or omitted entirely, lessens the effectiveness of the main idea and violates an important principle of good writing.

3. Euphony

It is sometimes necessary to rewrite what would otherwise be a perfectly good sentence because of the occurrence of some unfortunate combination of words.

PLAINTIFF'S EXHIBIT NO. 14—Continued

4. Tense of the verb

It is important not to mix the tenses of the verbs. Descriptions of apparatus are preferably written in the past tense, and descriptions of experiments should always be in the past tense. The use of the present tense should be confined to statements of theories, conclusions, etc. A good guide in determining the proper tense to be used is to avoid the use of the present tense wherever possible.

5. Person of the writer

The author should write consistently in the third person or the first person. If discreetly used the first person is perfectly proper, but most reports and articles are written in the third person. Excessive use of "I" or "the author" should be avoided. This may be done easily by changing the verb from the active to the passive voice. For example, "I observed a change in the volume" may be written "A change in the volume was observed." The editorial "we" should never be used.

6. Punctuation

Punctuation is for the purpose of making clear the relations of the different words, phrases, and clauses. Excessive use of commas should be avoided. A semicolon should never be used in place of a period.

Quotation marks are often employed to denote words and phrases used in an unusual or technical sense, but it is not good form to do this when the idea can be equally well conveyed without them, as is often possible by using a synonym. In any case, the unusual words should be put in quotation marks only the first time that they are used.

Parenthetical expressions serve a legitimate purpose, but in many cases could be easily avoided by use of commas, and in such cases they should be avoided.

For detailed instructions in regard to punctuation consult any good dictionary.

7. Capitalization

Capitalization is extensively treated in a circular of the Geological Survey entitled "Extracts from the Style Book of the Government Printing Office, Designed for the Use of Typewriter Operators Engaged in Preparing Manuscript for Printing."

Geographical names which are used in a descriptive sense and have lost their original significance should not be capitalized e. g.,

PLAINTIFF'S EXHIBIT NO. 14—Continued

portland cement, venetian red, etc. Except in a very few instances, e. g., bunsen burner, the names of persons when used in a similar way, are capitalized, e. g., Planck's law, Thomson bridge.

8. Hyphens

Hyphens connecting the parts of a compound word do not follow any definite rule, except when the compound is used as an adjective. If the combination of two words is used adjectively, the two are joined by a hyphen. When the noun is used as a noun, the adjective is written separately without a hyphen. Thus, "Radio circuits are of high frequency or of radio frequency." "High-frequency or radio-frequency generators are used." "A 500-volt generator."

As far as possible hyphens should be avoided by making a solid word (as crankshaft, not crank-shaft) or next best, two separate words (india rubber, not india-rubber). An adjective compound is usually hyphenated (alternating-current generator), but the rule is limited by the following exceptions: (1) When an adjective or participle is qualified by an adverb (as carefully prepared manuscript); (2) if the first word is qualified by an adverb (as extra high potential circuit); (3) if one of the words in the expression used as an adjective is capitalized (as Beckman thermometer corrections). It should always be borne in mind that the purpose of a hyphen is to make clear the meaning and connection of related words, and the use of a hyphen may often change the meaning, as in five-foot stools and five foot-stools.

Where words are brought together to form a new word, while retaining their individual significance, they should usually be hyphenated unless a solid word is possible. This applies to compound units, such as foot-pound, horsepower-hour, watergram-degree, gram-molecule.

An extensive list of compound words is given in the Style Book of the Government Printing Office, and this may be consulted for words in general use.

9. Miscellaneous style

Underline words which should be made specially prominent, as in defining important terms; enclose in quotation marks when defining a term but somewhat less emphasis is desired. In either case the word should be so designated only once and thereafter not specially distinguished.

PLAINTIFF'S EXHIBIT No. 14—Continued

Use metric units, or metric units followed by the English equivalents in parenthesis.

"Due" is an adjective. Do not use it as a participle. When introducing a clause where "owing" is proper, do not use "due."

Be very careful about such expressions as "obviously" or "it is readily seen." They are usually used at the points in a demonstration that are most difficult for the reader.

Be definite. For instance, in referring to previous work on the subject under discussion, state accurately the previous idea or work and person responsible.

"Precision" refers to the accidental errors of measurement and has to do with the variation of individual settings or results. "Accuracy" refers to the constant errors, and tells the reliability of the final result.

In stating accuracy or precision of results, do not say "to within" a certain value. Both "to" and "within" are prepositions. Say, rather, "within" a certain value.

Expressions such as "and so forth" and "etc." should be avoided.

IV. MECHANICAL FEATURES

1. Footnotes

Footnotes are usually references to the literature of the subjects discussed, but they may also be used for parenthetical discussions which amplify the text. Footnotes should be numbered consecutively from the beginning of the paper. In the manuscript each footnote should be written immediately below the line in which the reference mark appears and be separated from the text above and below by lines. Use the following style of punctuation in referring to a published article: The name of the journal, followed by comma, its volume (underscored, to indicate bold-face type), followed by another comma, and then the page preceded by "p.," semicolon, and last of all the year. Example: Phil. Trans. A, *175*, p. 217; 1884. When publishing in the same journal to which reference is made, say "This Journal." When referring to an article give the first page of the article, but referring to a particular part of a long article give the exact page in question. In referring to papers published in the bulletin of the bureau, which are also issued separately under the title "Scientific Papers," the reference should be in the following form: Bureau of Standards Scientific Paper No. 191. (Bull., *9*, p. 81; 1912.) Where a number of such references are being given and there is no possibility of misunderstanding, the abbreviated form may be used, S191.

PLAINTIFF'S EXHIBIT NO. 14—Continued

The preferred form for footnotes to tables is given in section 3, "Tables," just below.

2. Quotations

Quotations and citations should be literally correct, but errors or typography or orthography may be corrected. They should always be compared with the original and not taken from abstract journals. Short quotations should be put in quotation marks; longer quotations are set off from the main text by indentation and are single-spaced.

3. Tables

Tables, unless very small, are best put on separate sheets of paper. Rule the columns except for lines at extreme right and left, and make the box headings as simple and clear as possible. Each table should be numbered in Arabic numerals and should have an informing title. For footnotes to tables the reference marks are preferably superior letters instead of numbers. The footnotes are to be given immediately below the table rather than at the bottom of the page when printed.

4. Abbreviations

In the text of a paper, abbreviations should in general not be used except for units of measurement. Thus, usually write "electromotive force" not "emf," "potential difference" not "p. d."

The bureau has adopted certain abbreviations for the units of weight and measure in both the metric and English systems. These are given on page 13 of Circular 47. Abbreviations in the metric system are written without the period. The exponents 2 and 3 used to designate the square and cube of the unit, as cm^2=square centimeter, are used only with the metric system. When there is any doubt as to whether an abbreviation will be understood, the name of the unit or quantity should be written in full. Short words such as volt, calorie, gram, should usually be spelled out.

Chemical names and chemical symbols should not be used indiscriminately, the name being preferred to the symbol in the text. In a mathematical paper, a table of symbols should be included when there are many symbols.

5. Mathematical symbols and equations

Mathematical symbols and equations should be written with particular care. The arrangement of subscripts and exponents should be clear even to a person not familiar with mathematical expressions.

PLAINTIFF'S EXHIBIT No. 14—Continued

Exponents should be clearly indicated as superiors and subscripts as inferiors. When using Greek letters it is advisable to write the name of the letter in the margin if there is any chance of confusion as often arises between small alpha and small *a* and in numerous other cases. Equations to which reference is made should generally be numbered consecutively throughout the paper, the numbers being placed in parenthesis at the extreme right.

6. Proofreader's marks in manuscript

Proofreader's marks and methods should not be used in correcting manuscript unless a simplification is thereby effected. For example, if a period is omitted in the manuscript, it should be put in, and not located in the margin and its place indicated.

7. Correction of proof

Proof should be read very carefully, not only to discover departures from the manuscript but to discover any errors not previously detected. It is often possible for the author in reading the proof for the "sense" to detect slight ambiguities or inconsistencies which may have been overlooked before. However, changes that involve resetting of paragraphs should not be made unless they are of great importance.

A paper which has been carefully prepared both as to the thought and arrangement will require very few corrections in the proof. Changes made by the author in the proof are always costly and are charged against the bureau's allotment for printing. "Clear copy" will usually yield "clear proof." In such cases one galley proof and one page proof are sufficient and the paper will be published in the minimum time.

The conventional signs used in correcting proof may be found on pages 110 and 111 of the "Suggestions to Authors" published by the Geological Survey and in the Style Book of the Government Printing Office.

Wherever possible the correction should be written in the margin of the galley or page opposite the line in which it is required. Corrections should never be indicated in the body of the text as they might be overlooked. If it is necessary to draw a "skyrocket" line from the place needing correction to the place on the margin where the correction is given, care should be taken not to cross any other similar line. "Stop marks" are used to separate one marginal correction from another or to call attention to small signs such as

PLAINTIFF'S EXHIBIT No. 14—Continued

hyphens and commas. They should always be placed at the right of the mark to which they apply. When adding a period it is necessary to draw a circle around it; otherwise it would probably be overlooked.

V. MISCELLANEOUS TOPICS

1. Metric and English units

Metric and English units should not be used indiscriminately. Scientific papers should be written in metric units, but technologic papers and circulars often require the English units. In these it is well to give the metric equivalent, but care should be exercised to express the equivalents so as to convey an immediate impression to the reader. For example, to say the cost of street lighting is 20 cents per running foot of curb (1 foot=0.3 meter) does not give the impression desired, which is 66 cents per meter. In giving equivalents of English and metric units authors should avoid using more figures than the circumstances require. For example, one long ton equals 1.01604704 metric tons, but this has too many decimals for most purposes. Often the one ton may be written as the approximate equivalent of the other. In giving equivalents for articles manufactured as standard sizes in one system, excess figures in the equivalent should not be given, for example, a 3-inch rod is about 7.5 cm., which is a sufficient equivalent. Similarly for the thermometer scales 42° F.=5.5° C. but 42.00°=5.555° C.

2. Acknowledgments

An acknowledgement of assistance, etc., should not be included unless there is real reason for it. It is a rule of the department that services performed by assistants in the course of their regular duties require no acknowledgment. In other cases the ordinary rules of courtesy in regard to scientific publications apply.

General acknowledgments of assistance, etc., should be given at the end of the body of text immediately preceding summary. Where special assistance has been rendered in connection with some particular part of the work, a statement to this effect may properly be included in the text, or in a footnote, according to circumstances.

3. Publication outside the bureau

Papers giving accounts of work done at the bureau should in general be published by the bureau. Short papers on incidental matters may properly be published outside without publication by the bureau.

PLAINTIFF'S EXHIBIT No. 14—Continued

In any case where the reprints would be needed for distribution in answer to inquiry, etc., the paper should, of course, be published by the bureau.

The bureau encourages the publication of practically all of its work in appropriate scientific and technical journals. In this way the papers reach another circle of readers, and are more certain of being accessible in later years. It is not always desirable to publish papers in as extended a form in outside journals as in the bureau publications.

All papers published outside the bureau must first be approved for publication by the editorial committee. No exception to this rule is *permitted*.

4. Length of papers

The number of long papers submitted to the editorial committee has increased greatly during the last few years and the funds available are not sufficient to keep pace with this increased supply. The preparation of papers which are of the nature of text-books, treatises, monographs, or circulars of information should be undertaken under the direction of the division organization, and a preliminary outline of the project should be submitted to the editorial committee for approval.

Papers giving the results of research work should be made as brief as is consistent with clearness. The result of a research is usually to establish certain conclusions, and enough information must be given concerning the method of working and the results obtained to enable the reader to judge as to the validity of the conclusions. The presentation of all observations made in the course of a research is in most cases evidence of the author's inability to understand the significance of his own work. In a few cases, where the work relates to fundamental constants, the experimental data may be given in detail.

PLAINTIFF'S EXHIBIT No. 15

LEW:AN
I–6

RADIO LABORATORY,
BUREAU OF STANDARDS,
February 23, 1921.

Guide to radio laboratory, Bureau of Standards, and associated radio laboratories

DEPARTMENT OF COMMERCE, BUREAU OF STANDARDS, ELECTRICAL DIVISION (DIV. 1), RADIO COMMUNICATION SECTION (SEC. 6)

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PLAINTIFF'S EXHIBIT No. 15—Continued

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Library and exhibit of radio publications.
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SIGNAL CORPS RESEARCH LABORATORY---------- 110 to 113
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PLAINTIFF'S EXHIBIT No. 16

WAR DEPARTMENT,
Washington, June 14, 1921.

F. F. 113/2199—A—Air Service.

The honorable the SECRETARY OF THE TREASURY,
(Through the Secretary of Commerce).

SIR: Referring to the provisions of the act making appropriations for fortifications and other works of defense, etc., approved May 21, 1920, it is requested that the sum of $267,500 be transferred on the books of the Treasury Department, from the war ledger to the credit of the Department of Commerce, for direct expenditure by the Bureau of Standards under the appropriation "Air Service Army, 1921" to cover the cost of certain experimental projects for the Air Service of the Army.

Respectfully,

(Signed) J. M. WAINWRIGHT,
Assistant Secretary of War.

B

Approved to be placed to the credit of Industrial Research, Bureau of Standards, 1921.

Secretary of Commerce.

SWS

Transfer of funds to the Department of Commerce for expenditure under the direction of the director, Bureau of Standards, covering the following experimental projects:

PLAINTIFF'S EXHIBIT No. 16—Continued

Production of hydrogen	$15,000
Development of gas instruments	5,000
Development and testing of fabrics, cements, seams, and coatings	5,000
Chemical analysis and development of new proofing and coating materials—substitutes for goldbeater's skins and rubber cements	10,000
Textile section—physics of balloon fabrics, textiles, and mechanical tests	7,500
Investigation of cylinder valves, safety-release device, safety disks, fusible plugs	4,000
Investigation of wind screens	3,000
Investigation of parasitic resistance of airships, cars, and rigging	3,500
Altitude laboratory tests	25,000
Carburetion research—metering characteristics, condition of intake charge, physical constants of engine fuels, effects of pulsating flow	8,000
Ignition research—voltage required to produce ignition, insulation under supercharging, spark intensity, electrical characteristics of ignition systems and of starting systems	6,000
Cooling systems—airship temperature compensation and water ballast recovery; muffling systems; aircraft radiators; fundamental efficiencies of air-cooling systems	45,000
Lubrication research—fractionation of oils, consistency, at low temperatures, deterioration, carbonization, body, friction-machine tests	15,000
Combustion research—rates of combustion, limits of inflammability, ratio of specific heats	6,000
Astronomical aircraft instruments—sextants, position finder, altitude and azimuth indicator, methods of reducing, observations	10,000
Ground speed and drift indicators	5,000
Air-speed indicator for dirigibles	3,000
Volume indicator for dirigibles	2,500
Precision altimeter	2,500
Precision barograph	2,500
Temperature compensated thermobarograph	2,500
Drift and hysteresis in aneroid diaphragms—vacuum boxes	3,000
Investigation of Bourdon tubes	2,000
Recording rate of climb indicator; combined statiscope and rate of climb indicator	5,000
Mechanical statiscope	2,000
Distant-reading compass	2,500
Magnetic compass	2,500
Electric turn indicator	3,000
Distant reading tachometer	3,500
Bomb sight for dirigibles	3,500
Gyro stabilizers for bomb sights and ground speed indicators (planes and dirigibles)	8,000
Standard field testing sets	2,500
Balloon and airship manometers	1,500
Sound reflection instruments for fog landing	4,000
Earth inductor compass	4,000
Earth inductor latitude indicator	3,500
Radio direction finding research: elimination of ignition interference	5,000
Visual indicator for radio signals	3,500
Electrical aircraft altimeter (fog landing)	3,000
Transmission of directed radio waves from ground	5,000

PLAINTIFF'S EXHIBIT No. 16—Continued

General aircraft radio problems—antenna constants, position of aircraft by ground stations, transmitting sets, etc	$6,000
Airship bomb control and marine torpedo control by radio	2,500
Metal spraying investigation (prevention of corrosion, protect fabrics, etc.)	3,500
Use of inert exhaust gases in metal spraying	2,500
	$267,500

PLAINTIFF'S EXHIBIT No. 16–A

(In reply please quote file No. APJ211472 C1.)

WAR DEPARTMENT,
OFFICE OF THE DIRECTOR OF AIR SERVICE,
Washington, June 13, 1921.

DIRECTOR, BUREAU OF STANDARDS,
Department of Commerce, Washington, D. C.

SIR: The Chief of Air Service directs that you be advised that the sum of $267,500.00 has been set aside under allotment A–PJ–211472 PM–1653 for transfer to the Department of Commerce for expenditure under the direction of the Director, Bureau of Standards, to cover the experimental projects designated on attached list.

This fund will be transferred in accordance with the "act making appropriations for fortifications and other works of defense," approved May 21, 1920, and which provides that funds so placed shall remain available for a period of two years unless sooner expended.

Request has been made on the Chief of Finance of the Army to request the Secretary of the Treasury to transfer the above amount to the credit of the Department of Commerce.

Very respectfully,

C. G. HALL,
Colonel, A. S.,
Chief, Procurement Division.

1 Enclosure.

PLAINTIFF'S EXHIBIT No. 16–B

(Ap./F Munitions 3137. Tel. War Br. 1867.)

WAR DEPARTMENT,
OFFICE OF CHIEF OF FINANCE,
Washington, D. C., June 14, 1921.

File No. F. F. 113/2199, B. Air Service.

From: Office of Chief of Finance, U. S. A.

To: The Bureau of Standards, Department of Commerce.

Subject: Transfer of funds on books of Treasury Department.

PLAINTIFF'S EXHIBIT No. 16–B—Continued

1. At the request of the Chief of Air Service, U. S. Army (F. F. 113/2199, Air Service), a letter has this day been prepared for the signature of the Assistant Secretary of War requesting the Secretary of the Treasury to transfer the sum of $267,500.00 on the books of the Treasury Department, from the war ledger to the credit of the Department of Commerce for direct expenditure by the Bureau of Standards under the appropriation "Air Service Army, 1921" to cover the cost of experimental projects given in the attached list.

2. This transfer has been requested under the provisions of the act making appropriations for fortifications and other works of defense, etc., approved May 21, 1920.

H. M. LORD,
Chief of Finance, U. S. A.
By GEO. R. TAYLOR,
Chief, Funding Division.

Funds to the Bureau of Standards for experimental projects:

Production of hydrogen	$15,000
Development of gas instruments	5,000
Development and testing fabrics, cements, seams, and coatings	5,000
Chemical analysis and development of new proofing and coating materials—substitutes for goldbeater's skins and rubber cements	10,000
Textile section—physics of balloon fabrics, textiles and mechanical tests	7,500
Investigation of cylinder valves, safety release device, safety disks, fusible plugs	4,000
Investigation of wind screens	3,000
Investigation of parasitic resistance of airships, cars, and rigging	3,500
Altitude laboratory tests	25,000
Carburetion research—metering characteristics, condition of intake charge, physical constants of engine fuels, effects of pulsating flow	8,000
Ignition research—voltage required to produce ignition, insulation under supercharging, spark intensity, electrical characteristics of ignition systems and of starting systems	6,000
Cooling systems—airship temperature compensation and water ballast recovery; muffling systems; aircraft radiators; fundamental efficiencies of air-cooling systems	45,000
Lubrication research—fractionation of oils, consistency, at low temperatures, deterioration, carbonization, body, friction machine tests	15,000
Combustion research—rates of combustion, limits of inflammability ratio of specific heats	6,000
Astronomical aircraft instruments—sextants, position finder, altitude and azimuth indicator, methods of reducing observations	10,000
Ground speed and drift indicators	5,000
Air speed indicator for dirigibles	3,000
Volume indicator for dirigibles	2,500
Precision altimeter	2,500
Precision barograph	2,500
Temperature, compensated thermobaragraph	2,500

PLAINTIFF'S EXHIBIT NO. 16–B—Continued

Drift and hysteresis in aneroid diaphragms—vacuum boxes	$3,000
Investigation of Bourdon tubes	2,000
Recording rate of climb indicator; combined statiscope and rate of climb indicator	5,000
Mechanical statiscope	2,000
Distant reading compass	2,500
Magnetic compass	2,500
Electric turn indicator	3,000
Distant reading tachometer	3,500
Bomb sight for dirigibles	3,500
Gyro stabilizers for bomb sights and ground speed indicators (planes and dirigibles)	8,000
Standard field testing sets	2,500
Balloon and airship manometers	1,500
Sound reflection instruments for fog landing	4,000
Earth inductor compass	4,000
Earth inductor latitude indicator	3,500
Radio direction finding research; elimination of ignition interference	5,000
Visual indicator for radio signals	3,500
Electrical aircraft altimeter (fog landing)	3,000
Transmission of directed radio waves from ground	5,000
General aircraft radio problems—antenna constants, position of aircraft by ground stations, transmitting sets, etc	6,000
Airship bomb control and marine torpedo control by radio	2,500
Metal spraying investigation (preventing of corrosion, protect fabrics, etc.)	3,500
Use of inert exhaust gases in metal spraying	2,500
	$267,500

APJ211472
Cl

JUNE 13, 1921.

DIRECTOR, BUREAU OF STANDARDS,
Department of Commerce, Washington, D. C.

SIR: The Chief of Air Service directs that you be advised that the sum of $267,500.00 has been set aside under allotment A–PJ–211472 P. M.–1653 for transfer to the Department of Commerce for expenditure under the direction of the Director, Bureau of Standards, to cover the experimental projects designated on attached list.

This fund will be transferred in accordance with the "act making appropriations for fortifications and other works of defense," approved May 21, 1920, and which provides that funds so placed shall remain available for a period of two years unless sooner expended.

PLAINTIFF'S EXHIBIT No. 16–B—Continued

Request has been made on the Chief of Finance of the Army to request the Secretary of the Treasury to transfer the above amount to the credit of the Department of Commerce.

Very respectfully,

C. G. HALL,
Colonel, A. S.,
Chief, Procurement Division.

1 inclosure.

THMane: AAA

CHIEF, ENGINEERING DIVISION, AIR SERVICE,
Washington, D. C., May 16, 1921.

CHIEF OF AIR SERVICE, *Washington, D. C.*

Transfer of funds to the Bureau of Standards for lighter-than-air engineering projects

1. Under date of April 22nd the Balloon and Airship Division submitted a suggested list of projects to be undertaken at the Bureau of Standards with funds remaining of the fiscal year 1920–1921. This program was gone over carefully in this division and in consultation with Lieut. Thompson, Mr. Burton, and Mr. Corbett of the Fort Omaha organization. Finally Lieut. J. P. Van Zandt was sent to the Bureau of Standards for the purpose of conferring with the authorities of the bureau in connection with this program, with the result that the program has been changed and modified. It is, therefore, recommended that funds be transferred to the Bureau of Standards from item 602.401, fiscal year 1920–1921, for the following projects:

Gas chemistry section

Project 1: Production of hydrogen (experimental plant at Trenton, N. J.)	$15,000
Project 2: Development of gas instruments (Gas analysis, purity testing, permeability testing, leak detectors, etc.)	5,000
Project 3: Development and testing of fabrics, cements, seams, and coatings	5,000
Project 4: Chemical analysis and development of new proofing and coating materials—substitutes for goldbeater's skins, for rubber cements, etc	10,000
Project 5: Textile section—physics of balloon fabrics, textiles, and mechanical tests	7,500

PLAINTIFF'S EXHIBIT No. 16-B—Continued

Engineering physics division

Project 6: Investigation of cylinder valves, safety release device, safety disks, fusible plugs	$4,000
Project 7: Investigation of wind screens	3,000
Project 8: Investigation of parasitic resistance of airships, cars, and rigging	3,500

Automotive power plant section

Project 9: Altitude laboratory tests	25,000
Project 10: Carburetion research—metering characteristics, condition of intake charge, physical constants of engine fuels, effects of pulsating flow	8,000
Project 11: Ignition research—voltage required to produce ignition, insulation under supercharging, spark intensity, electrical characteristics of ignition systems and of starting systems	6,000
Project 12: Cooling systems—airship temperature compensation and water ballast recovery; muffling systems; aircraft radiators; fundamental efficiencies of air cooling systems	45,000
Project 13: Lubrication research—fractionation of oils, consistency at low temperatures, deterioration, carborization, body, friction machine tests	15,000
Project 14: Combustion research—rates of combustion, limits of inflammability, ratio of specific heats	6,000

Aeronautic instrument section

Project 15: Astronomical aircraft instruments—sextants, position finder, altitude and azimuth indicator, methods of reducing observations	10,000
Project 16: Ground speed and drift indicators	5,000
Project 17: Air speed indicator for dirigibles	3,000
Project 18: Volume indicator for dirigibles	2,500
Project 19: Precision altimeter	2,500
Project 20: Precision barograph	2,500
Project 21: Temperature compensated thermobarograph	2,500
Project 22: Drift and hysteresis in aneroid diaphragms—vacuum boxes	3,000
Project 23: Investigation of Bourdon tubes	2,000
Project 24: Recording rate of climb indicator—combined statoscope and rate of climb indicator	5,000
Project 25: Mechanical statoscope	2,000
Project 26: Distant reading compass	2,500
Project 27: Magnetic compass	2,500
Project 28: Electric turn indicator	3,000
Project 29: Distant reading tachometer	3,500
Project 30: Bomb sight for dirigibles	3,500
Project 31: Gyro stabilizers for bomb sights and ground speed indicators (planes and dirigibles)	8,000
Project 32: Standard field testing sets	2,500
Project 33: Balloon and airship manometers	1,500

PLAINTIFF'S EXHIBIT No. 16–B—Continued

Sound section

Project 34: Sound reflection instruments for fog landing	$4,000
Project 35: Earth inductor compass	4,000
Project 36: Earth inductor latitude indicator	3,500

Radio section

Project 37: Radio direction finding research; elimination of ignition interference	5,000
Project 38: Visual indicator for radio signals	3,500
Project 39: Electrical aircraft altimeter (fog landing)	3,000
Project 40: Transmission of directed radio waves from ground	5,000
Project 41: General aircraft radio problems, antenna constants, position of aircraft by ground stations, transmitting sets, etc	6,000
Project 42: Airship bomb control and marine torpedo control by radio	2,500

Gas chemistry and metal spraying section

Project 43: Metal spraying investigation (prevention of corrosion, protect fabrics, etc.)	3,500
Project 44: Use of inert exhaust gases in metal spraying	2,500
Total	$267,500

2. It will be noted that the above items total $267,500. The Fort Omaha organization is now endeavoring to perfect arrangements for the expending of funds totaling $151,750. This gives a grand total of $419,250. It is understood that the appropriation available is $393,299.70.

3. The estimate for the expenditure of Fort Omaha funds is only an estimate and definite amount can not be determined until bids are received for certain items. It is therefore felt that satisfactory arrangements are in process for properly expending the total remaining in the appropriation Item 602.401.

THURMAN H. BANE,
Major, A. S.

PLAINTIFF'S EXHIBIT No. 16–C

VI–O/1123 MAY 19, 1921.

Major THURMAN H. BANE,
Engineering Division, Air Service,
War Department,
McCook Field,
Dayton, Ohio.

Subject: Funds for development of lighter-than-air program.

MY DEAR MAJOR BANE:

1. I am in receipt of your letter of May 16, enclosing a copy of your letter of the same date to the Chief of the Air Service, in

PLAINTIFF'S EXHIBIT No. 16–C—Continued

which you recommend the allotment of $267,500 to the Bureau of Standards for development work in connection with the lighter-than-air program outlined in that letter.

2. The program as outlined is entirely satisfactory to us, and I wish to express my appreciation of your proposal that the Bureau of Standards should carry out this important program in cooperation with the Engineering Division of the Air Service. If your proposal meets with the approval of the Chief of the Air Service, we shall proceed immediately to formulate a specific program for each project and to present these programs through your engineering representative to the proper members of your engineering staff for their consideration.

3. I am glad to learn that representatives of your organization will make frequent trips to the bureau, as we have found such consultations to be very helpful in the effective prosecution of the work.

Respectfully,

(Signed) S. W. STRATTON,
Director.

PLAINTIFF'S EXHIBIT No. 16–D

VI–O/1123 MAY 19, 1921.

Major THURMAN H. BANE,
Engineering Division, Air Service,
War Department,
McCook Field,
Dayton, Ohio.

Subject: Funds for development of lighter-than-air program.

MY DEAR MAJOR BANE:

1. I am in receipt of your letter of May 16, enclosing a copy of your letter of the same date to the Chief of the Air Service, in which you recommend the allotment of $267,500 to the Bureau of Standards for development work in connection with the lighter-than-air program outlined in that letter.

2. The program as outlined is entirely satisfactory to us, and I wish to express my appreciation of your proposal that the Bureau of Standards should carry out this important program in cooperation with the Engineering Division of the Air Service. If your proposal meets with the approval of the Chief of the Air Service, we shall proceed immediately to formulate a specific program for each project and to present these programs through your engineering representative to the proper members of your engineering staff for their consideration.

PLAINTIFF'S EXHIBIT No. 16–D—Continued

3. I am glad to learn that representatives of your organization will make frequent trips to the bureau, as we have found such consultations to be very helpful in the effective prosecution of the work.

Respectfully,

(Signed.) S. W. STRATTON,
Director.

PLAINTIFF'S EXHIBIT No. 16–E

WAR DEPARTMENT,
AIR SERVICE,
ENGINEERING DIVISION,
McCOOK FIELD,
Dayton, Ohio, May 16, 1921.

MY DEAR DR. STRATTON: I am forwarding herewith copy of a letter sent the Chief of Air Service this date, recommending the allotment of $267,500 to the Bureau of Standards for the development listed during the next two years. The funds allotted will be available under the terms of the fortification act for use during a period of two years. In view of the fact that the data supplied Lieut. Van Zandt, by your organization, calls for amounts of money in many cases considerably in excess of the amounts it has been possible to allot, it is requested that you have your organization submit a revamped program of the developments they intend to undertake with the moneys that will be allotted to the bureau in case the Chief of Air Service approves the recommendation of this division.

As you know, lighter-than-air engineering has been transferred to McCook Field and the Engineering Division is now undertaking to coordinate and direct all lighter-than-air experimental work. We are therefore anxious to start in with a perfectly definite and explicit program reference lighter-than-air matters. We propose to handle the lighter-than-air problems in the same way that we have hitherto handled the heavier-than-air problems at the bureau. We will continue to keep a representative at the bureau and members of this organization will make frequent trips there for consultation, etc. We anticipate no difficulty and we trust that you will experience no embarrassment in the transfer of the control of these activities.

Sincerely yours,

(Sgd.) THURMAN H. BANE,
Major, A. S.

To: Dr. S. W. STRATTON,
% The Bureau of Standards,
Washington, D. C.

PLAINTIFF'S EXHIBIT No. 17

MAY 25, 1921.

From: The Chief of Air Service.

To: The Chief, Engineering Division, McCook Field, Dayton, Ohio.

Subject: Transfer of funds to the Bureau of Standards for lighter-than-air engineering projects.

1. The Chief of Air Service has approved the experimental program outlined in your letter of May 16, 1921, subject: Transfer of funds to Bureau of Standards for lighter-than-air engineering projects. Steps have been taken to immediately transfer to the Bureau of Standards the sum of $267,500 to cover the program outlined in your letter above referred to.

2. There has also been made available under item 0602.401, Experimentation and research, balloons, airships, and accessories, sufficient funds, which with the remaining balances under this item after deducting the amount transferred to the Bureau of Standards, will fully take care of the program prepared at Fort Omaha, Nebraska, which amounts to $153,750, and which is also referred to in your letter of May 16.

By direction of the Chief of Air Service.

(Sgd.) W. H. FRANK,
Major, Air Service,
Acting Executive.

Transfer of funds to the Bureau of Standards for experimental projects:

Production of hydrogen	$15,000
Development of gas instruments	5,000
Development and testing of fabrics, cements, beams, and coatings	5,000
Chemical analysis and development of new proofing and coating materials—substitutes for goldbeater's skins and rubber cements	10,000
Textile section—physics of balloon fabrics, textiles, and mechanical tests	7,500
Investigation of cylinder valves, safety release device, safety disks, fusible plugs	4,000
Investigation of wind screens	3,000
Investigation of parasitic resistance of airships, cars, and rigging	3,500
Altitude laboratory tests	25,000
Carburetion research—metering characteristics, condition of intake charge, physical constants of engine fuels, effects of pulsating flow	8,000
Ignition research—voltage required to produce ignition, insulation under supercharging, spark intensity, electrical characteristics of ignition systems and of starting systems	6,000
Cooling systems—airship temperature compensation and water ballast recovery; muffling systems; aircraft radiators; fundamental efficiencies of air-cooling systems	45,000

PLAINTIFF'S EXHIBIT No. 17—Continued

Lubrication research—fractionation of oils, consistency, at low temperatures, deterioration, carborization, body, friction-machine tests	$15,000
Combustion research—rates of combustion, limits of inflammability ratio of specific heats	6,000
Astronomical aircraft instruments—sextants, position finder, altitude and azimuth indicator, methods of reducing observations	10,000
Ground speed and drift indicators	5,000
Air-speed indicator for dirigibles	3,000
Volume indicator for dirigibles	2,500
Precision altimeter	2,500
Precision barograph	2,500
Temperature compensated thermobaragraph	2,500
Drift and hysteresis in aneroid diaphragms—vacuum boxes	3,000
Investigation of Bourdon tubes	2,000
Recording rate of climb indicator; combined statiscope and rate of climb indicator	5,000
Mechanical statiscope	2,000
Distant reading compass	2,500
Magnetic compass	2,500
Electric turn indicator	3,000
Distant reading tachometer	3,500
Bomb sight for dirigibles	3,500
Gyro stabilizers for bomb sights and ground-speed indicator (planes and dirigibles)	8,000
Standard field testing sets	2,500
Balloon and airship manometers	1,500
Sound-reflection instruments for fog landing	4,000
Earth inductor compass	4,000
Earth inductor latitude indicator	3,500
Radio direction-finding research; elimination of ignition interference	5,000
Visual indicator for radio signals	3,500
Electrical aircraft altimeter (fog landing)	3,000
Transmission of directed radio waves from ground	5,000
General aircraft radio problems—antenna constants, position of aircraft by ground stations, transmitting sets, etc	6,000
Airship bomb control and marine torpedo control by radio	2,500
Metal spraying investigation (prevention of corrosion, protect fabrics, etc.)	3,500
Use of inert exhaust gases in metal spraying	2,500
	267,500

PLAINTIFF'S EXHIBIT NO. 18

LEW:MHC

RADIO LABORATORY,
BUREAU OF STANDARDS,
July 29, 1921.

RADIO PROJECTS FOR U. S. AIR SERVICE—OUTLINE OF WORK

Washington	Dayton
37. Radio direction finding research:	
Design and assemble parts of d. f. for Martin bomber of Eq. Sec.	Install d. f. in Martin bomber of Eq. Sec. Calibrate d. f. on plane various *'s & loads.
Construct d. f. for receiving from planes. (See SCR122.)	Make d. f. study of waves from planes, check radio and visual observations. Meas. direc. and sig. intensity.
Construct signal intensity meas. apparatus.	Make d. f. tests along model aerial highway.
Make up shielded rotating coupler. Study effect of detuning crossed coils (primary).	
Study resonance wave coils.	
Elimination of ignition interference:	
Collect materials for sound proof compartment.	Construct sound proof compartment in plane.
(Experiment with balancing and compensating methods for present liberty engine installations with battery ignition.)	Install balancing or compensating apparatus on plane.
Learn about S. C. experiments with metal point.	
38. Visual indicator for radio signals:	
Investigate vibration galvanometer. (See Hoxie and L. V. King.)	Install final type of indicator on plane and test in service.
Construct modification of Eckhardt recorder.	
Amplifier to operate light or relay.	
Amplifier using small receiving tubes.	

PLAINTIFF'S EXHIBIT No. 18—Continued

39. Electrical aircraft altimeter (fog landing):

Study condenser antenna altimeter, theor. and exp.
Set up transmitting apparatus for double-coil note variation method.
Investigate earth inductor altimeter, and prepare report on same.
Install condenser antenna altimeter on plane.
Transmit to airplane in flight.

40. Transmission of directed radio waves from ground:

Collect apparatus for horizontal and vertical transmission.
Devise methods for decreasing waste power.
Receive, on low inverted L antennæ: from large crossed coils.
Obtain synchronized transmitters by power amplification.
Reflection of short waves.
Measure rec'd signals using captive balloon in vicinity of antennæ to transmit horizontally and vertically.

41. General aircraft radio problems:

Study of power tubes, for CW, ICW, and phone.
Radiotelephony with arcs.
Construct apparatus for measuring antenna constants.
Position of aircraft by ground stations, study radiation from planes.
Aircraft radio information.
Measure direction of signals transmitted from captive balloon.

PLAINTIFF'S EXHIBIT No. 18—Continued

42. Airship bomb control and marine torpedo control:

Devise secret signaling system to use with Air Service selector.
Inspect Hammond receiving set.
Seek relay to operate from 10 to 12 times per second on 500 microamperes.

PLAINTIFF'S EXHIBIT No. 19

Department of Commerce. Scientific Papers of the Bureau of Standards. S. W. Stratton, Director. No. 381. An Electron Tube Transmitter of Completely Modulated Waves, by Lewis M. Hull, Associate Physicist, Bureau of Standards. June 18, 1920.

AN ELECTRON TUBE TRANSMITTER OF COMPLETELY MODULATED WAVES

By Lewis M. Hull

The electric waves used in radio transmission are sometimes classified as undamped or continuous, and damped or interrupted waves. A more fundamental classification would separate radio-frequency waves into the two general types: Unmodulated, which are always continuous, and modulated, which may be continuous or discontinuous. Under the first group come the single frequency, sinusoidal oscillations which are obtained under certain operating conditions from a simple electron tube oscillator, and the constant amplitude but uniformly distorted waves of arc transmission, which can be resolved into the sum of a radio-frequency fundamental oscillation and a number of frequencies which are integral multiples thereof.

All modulated waves can be thought of as a single radio frequency whose amplitude is a function of time which may be periodic, as in the case of a "sine-modulation" and spark transmission, or which may be irregular, as in the case of voice modulation (radio telephone), and which in any case can be expressed by the sum of a constant term, an audio-frequency fundamental and a series of audio-frequency harmonics. The audible response of a detector to modulated radio-frequency oscillations depends upon the degree of modulation. In the case of spark transmission this means that the response depends, to a certain degree, upon the maximum amplitude of the radio-frequency constituent, since the radio frequency is always completely modulated; that is, periodically reduced to zero.

PLAINTIFF'S EXHIBIT NO. 19—Continued

In order to utilize a radio-frequency oscillation of given power most effectively in a nonoscillating receiving system it must be completely modulated, the periodic reduction to zero occurring at a suitable audio frequency. Radio-frequency harmonics, manifested by distortions in the shape of the radio-frequency or carrier wave limit the total power radiated by a transmitter at the single frequency to which the receiver is tuned. Audio-frequency harmonics, manifested by distortions in the envelope of the radio-frequency oscillations from sinusoidal form, determine the response of any amplifying and rectifying detector.

There are two possible methods of operating an electron tube generating system so as to furnish a completely modulated output: (1) The use of a direct supply voltage in connection with a mechanical interrupter or "chopper," which periodically breaks the supply circuit, causing the antenna current to be reduced to zero; (2) the use of an alternating audio-frequency supply voltage. If the frequency of the supply voltage be F and the peak value be E_b, then the plate is positive with respect to the filament F times per second while the supply voltage rises from O to E_b volts, and negative F times per second while the supply voltage falls from O to $-E_b$ volts. The antenna current is maintained for a half cycle when the plate is positive and is reduced to zero a greater part of the half cycle when the plate is negative.

The first method requires a source of high direct voltage which may be inconvenient if high-power tubes are used. With the second method the whole system can be operated from any audio-frequency generator with suitable transformers for the high-voltage plate and the relatively low-voltage filament. The note produced by telephone receivers actuated by the rectified output from the transmitter corresponds to the frequency F. Consequently a desirable value for F would be 800 cycles per second, since most audio-frequency receiving apparatus is designed for best operation at about that frequency. If no 800-cycle generator is available, a 500-cycle machine can be used.

No power is taken from the plate supply transformer when the plate is negative. Power is consumed by the tube while the plate voltage varies from zero to the peak value of the alternating voltage. When the tube is operated over such a wide range of plate voltages, the usual square relation between plate voltage and output power does not hold throughout the whole range, and the adjustment of transmitter circuits for maximum output can be obtained only by trial and not by calculation from theoretical considerations.

A transmitter of this description has been designed and built at this bureau. The set fulfills the following requirements: (1)

PLAINTIFF'S EXHIBIT No. 19—Continued

Use of a single, type " P " pliotron, with a 500-cycle, 150-volt alternator; (2) power output exceeding 200 watts in an antenna having 8 to 15 ohms resistance and a natural wave length below 200 m; (3) a readily adjustable range of wave lengths from 500 to 1,000 m; (4) transmission of completely modulated waves, making possible their reception with crystal detectors; (5) sharply tuned waves in order to avoid excessive interference over long series of tests. The set has been used in fog-signalling and direction-finding experiments, and in transmission tests carried out as part of an investigation of wave propagation.

In designing the set the average power output in a given antenna was taken as the criterion of its merit as a transmitter of radio waves. The *form* in which the power is radiated determines to a

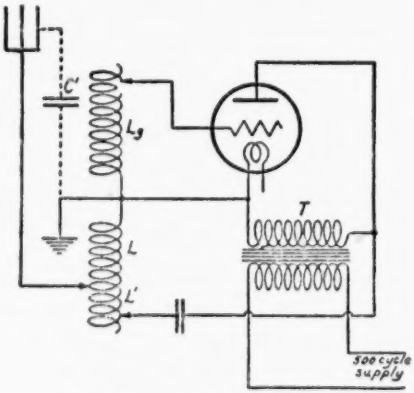


FIG. 1a.—Direct-coupled circuit

large extent what type of receiving circuits should be employed to utilize this power effectively. However, if it be understood that an appropriate receiving circuit is to be used, the rms current output in an antenna of given radiation resistance at a given wave length determines the merit of any transmitter of modulated or unmodulated waves. (There is, of course, an exception to this statement in the case of radiotelephone signals, in which the interpretation of the signal depends upon the kind and degree of modulation.)

There are no sound theoretical reasons why a transmitting system with sinusoidal supply voltage can not be adjusted to maximum current output using either a capacity coupled, direct coupled, or inductively coupled generating circuit. However, it was found experimentally, with 500-cycle power supply, that any inductively coupled circuit, either with series or with parallel power supply, was

PLAINTIFF'S EXHIBIT No. 19—Continued

equally suitable and conveniently adjustable. Fig. 1 (*a*), (*b*), and (*c*) show the essential connections of three circuits which were found to be serviceable.

In all three figures T is the 500-cycle supply transformer furnishing the alternating plate voltage and C' is the total effective capacity of the oscillatory (antenna) circuit.

Fig. 1 (*a*) shows a direct-coupled circuit with parallel power supply. The secondary of the supply transformer, T, may furnish a sufficient choke for the radio-frequency plate current. In some transformers the distributed capacity of the secondary winding is so great as to by-pass the radio-frequency plate current, and a radio-frequency choke coil must be inserted in series with this winding. C is a stopping condenser with negligible radio-frequency reactance;

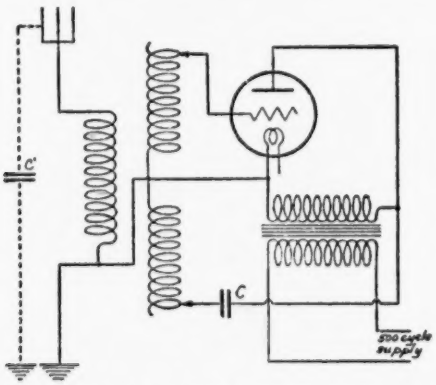


FIG. 1b.—Inductively coupled circuit

it should be noted that it is possible to approach 500-cycle resonance in the circuit formed by the secondary of the transformer, T, the condenser, C, and the plate coupling inductance, causing an alternating voltage to be applied between plate and filament much higher than the secondary voltage of the transformer. This condition may be disastrous for the tube if it is not taken into account in determining the transformer ratio.

In Fig. 1 (*b*) and (*c*) are shown inductively coupled (Meissner) circuits with parallel and series power supply. In the case of series power supply the condenser C acts as a by-pass condenser, and its 500-cycle reactance should be large, unless audio-frequency resonance is required to build up the supply voltage. In every case one side of the secondary of the supply transformer is grounded.

For convenience in shifting wave lengths and adjusting to maximum output the inductively coupled circuit with parallel power

PLAINTIFF'S EXHIBIT No. 19—Continued

supply has been used extensively. It is found necessary, in any case, with high effective values of supply voltage, to make the coupling of the antenna circuit with the plate circuit much greater than its coupling with the grid circuit, for maximum output. Since a certain minimum value of grid voltage must be fed back into the tube to sustain the oscillations, this necessitated the use, with the direct coupled system, of a large number of turns in the plate-filament circuit. In a transmitter used at relatively short wave lengths, only a few turns can be included in the antenna circuit, and the plate coupling must be supplied largely by mutual inductance between the antenna coil and the inductance L' (fig.

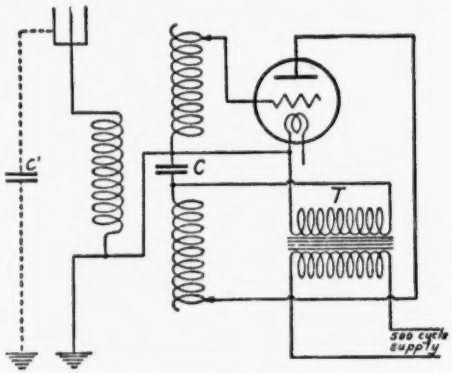


FIG. 1c.—Inductively coupled circuit

1, (*a*)). If the Meissner circuit be used, the antenna coil can be made entirely separate from the coupling coils and can be placed around them, giving a higher mutual inductance per turn of the plate coupling coil than if the antenna, plate, and grid inductances were of the same coil. It was found also that the plate and grid coupling could be varied separately, or together, without changing appreciably the wave length of transmission; similarly, the wave length could be varied without changing the relative coupling values.

Fig. 2 is a diagram of connection of the final form of this transmitter as put into service at Windmill Point Light, Chesapeake Bay. Attention is called to Figs. 3 and 4, showing the set completely assembled. It should be stated in connection with these photographs that this particular set was assembled upon a panel designed for a different purpose and might have been constructed in much more compact form. Below are given the dimensions and

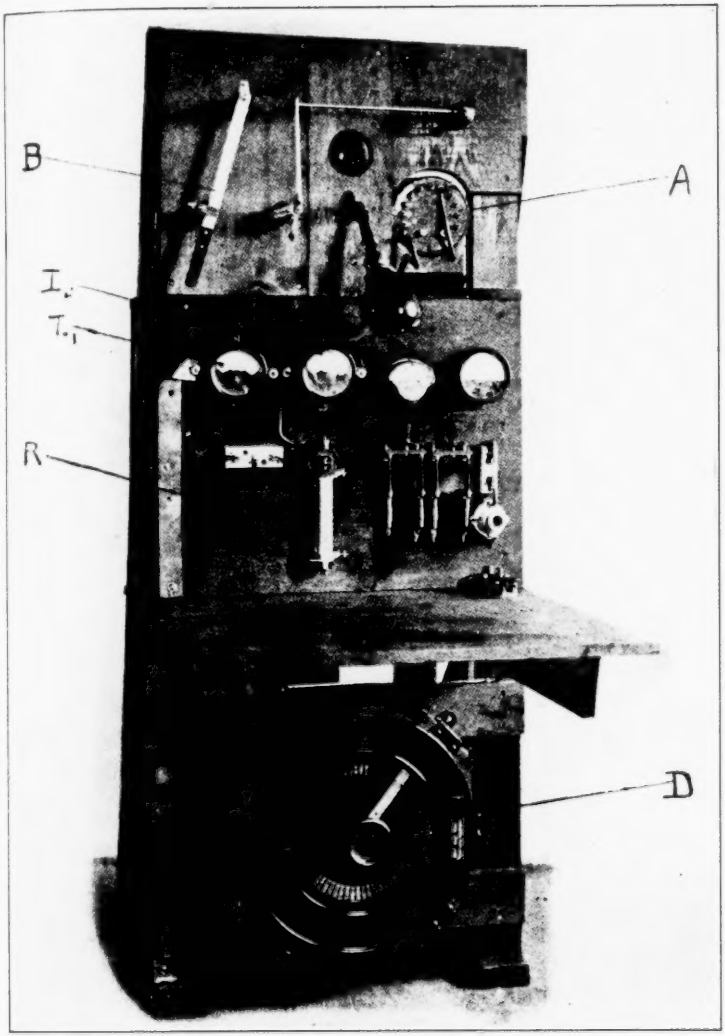


FIGURE 3.—Transmitter, front view

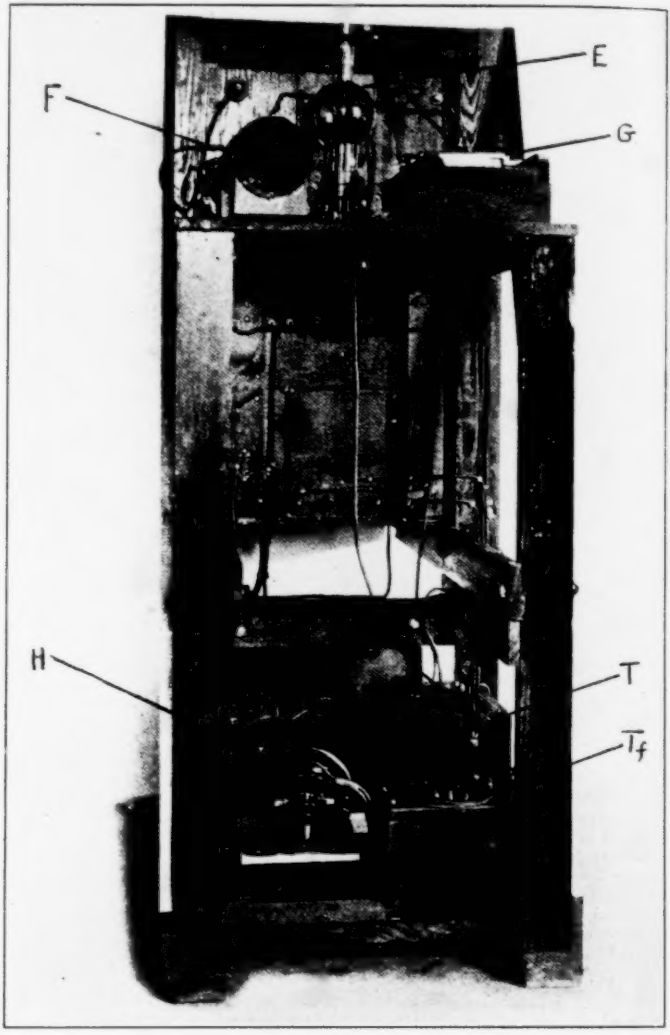


FIGURE 4.—Transmitter, rear view

PLAINTIFF'S EXHIBIT No. 19—Continued

details of construction of the various parts. The letters refer to Figs. 2, 3, and 4.

Owing to the fact that the 500-cycle voltage, when using a 2 kw alternator, dropped enough to decrease the filament current by as much as 15 per cent when the load was thrown on in the plate

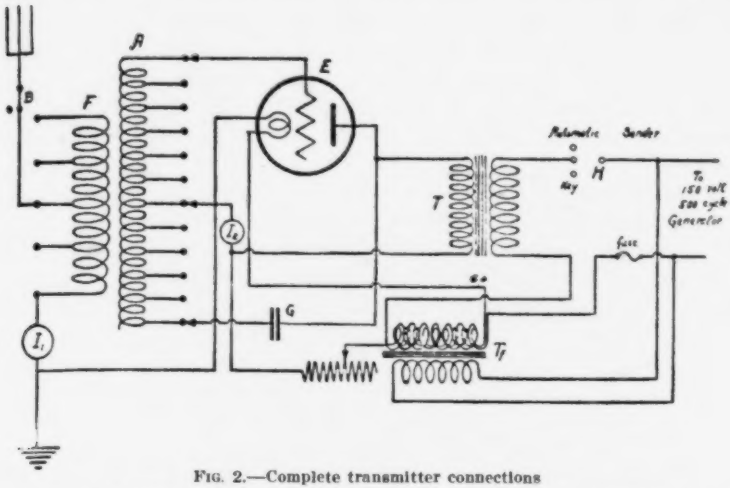


FIG. 2.—Complete transmitter connections

A, Plate and grid coupling coils; continuous coil wound on fiber tube 5½ inches in diameter; 80 turns No. 18 solid wire spaced one-eighth inch apart; end taps brought out every 5 turns on grid side and every 10 turns on plate side of coil.

B, Antenna switch.

D, Generator field rheostat.

E, Electron tube, type *P* pliotron.

F, Antenna coil; 30 turns, litzendraht, wound on fiber tube 6⅜ inches in diameter; taps brought out every 2 turns; mounted so as to slide over coupling coil in order to vary mutual inductance.

G, Stopping condenser; mica; C=0.004 uf.

H, Automatic sender, driven by direct-current motor, which is supplied from the field circuit alternator.

I_1, Antenna ammeter.

I_2, Filament ammeter.

R, Filament rheostat.

T, Supply transformer, 2 kva.; ratio of turns 40/1; full-load voltages 160/6500.

Tf, Filament transformer, special construction, shown in detail in Fig. 5. The main windings consist of 200 turns No. 16 d. c. c. wire on the primary side, connected across the 180-volt supply, and 120 turns No. 16 d. c. c. wire on secondary side, connected to filament circuit.

circuit, it was found necessary to include in the filament transformer a series compensating winding. This is rendered doubly imperative by the fact that when operating a tube at high plate voltage, the power output changes to a much greater extent with slight changes in emission than when operating at lower plate voltages. The system is always kept adjusted for maximum output at the maximum

PLAINTIFF'S EXHIBIT NO. 19—Continued

safe filament current, I, rms[1] = 3.6 amperes, and even a slight decrease in this current decreases the power output considerably, and the current output to a corresponding extent. In order to be able to adjust this transformer to give suitable compensation for the drop in primary voltage, and still be able to use it at different values of generator voltage, when it is found desirable to transmit at reduced power, it is necessary to make the number of turns in the compensating winding adjustable. The compensating winding of the transformer shown in Fig. 5 is composed of 100 turns No. 16 d. c. c. wire, with a tap every 12 turns from 30 to 100. The filament rheostat makes it possible to adjust the filament current for any steady value of primary voltage on the transformer; the series compensating winding makes it possible so to adjust the transformer to the supply circuit that the filament current reaches a safe maximum when the load is thrown on. If sufficient power is available from the generator, it is advisable to overcompensate the transformer, making it possible to heat the filament at reduced current except when the key is pressed.

The transmitter described in this paper was designed to operate at short wave lengths. The performance of such a system at short waves is limited by two factors, first, the electrostatic capacity between elements of the electron tube, which may provide a reactive shunt for the oscillatory circuit; second, the approximate linear relation between power output, resistance, and capacity. Consider any short portion of the wave train when the amplitude of the supply voltage may be considered constant so far as the radio-frequency oscillations are concerned. It has been shown [2] that the output power is given for any tube by

$$P_o = \frac{I}{R}\frac{L}{2C} f(P_o)$$

where R, L, and C are the resistance, inductance, and capacity of the antenna and f is a function which depends upon the characteristics of the tube and upon the plate and grid coupling. Over a certain range of operation the function f, which involves the oscillating grid voltage as dependent upon the antenna current and coupling, is found to be a direct linear function. Then the output power varies inversely with the antenna capacity and with the antenna resistance. Assuming constant L, since a change in L involves a change in the function f, it is evident that if C is made small, as is the case at short wave lengths, R must be increased in order to obtain maximum output. It

[1] rms = root mean square.

[2] B. S. Scientific Paper No. 355.

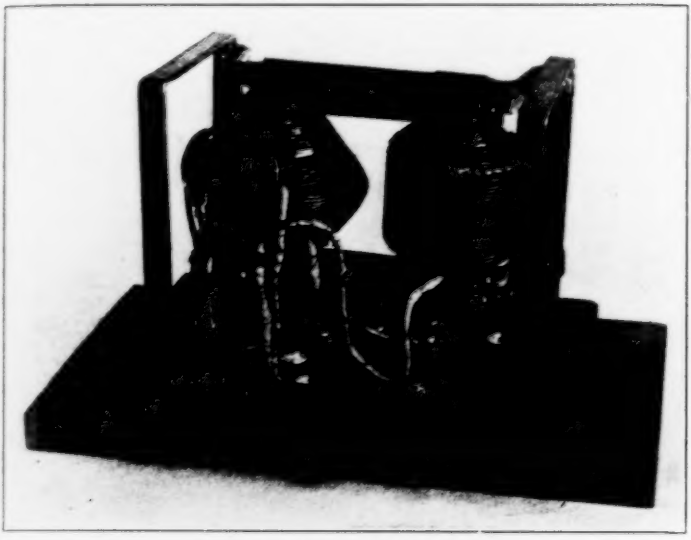


FIGURE 5.—Filament circuit transformer

PLAINTIFF'S EXHIBIT No. 19—Continued

may be impossible to obtain maximum output from a tube in a given antenna of low resistance at short wave lengths, particularly in view of the fact that the total effective resistance decreases with increasing frequency.

The following table gives a record of the performance of the set at short wave lengths supplying an antenna having a capacity of approximately 0.004 μf and a resistance, at 500 m, of 10 ohms. In the column "Power output" it is assumed that this resistance remained constant from 600 to 420 m, which is not a particularly rash assumption, since the antenna was of such short natural period as to make the radiation resistance a small part of the total. The procedure of the test was to maintain a constant antenna capacity and change the wave length by varying the antenna inductance, adjusting the maximum output by changing the coupling.

Wave length	Input	Rms filament current	Antenna current	Power in antenna	Over-all efficiency transformer to antenna inclusive
	Watts	*Amperes*	*Amperes*	*Watts*	*Per cent*
600	1,050	3.5	5.1	286	35
500	1,300	3.5	5.0	275	21
480	1,120	3.5	4.0	*176	*15.7
420	1,100	3.5	2.9	*93	*8.5

*Approximate.

It should be noted that the power input and efficiency as computed include the power expended in the filament and filament transformer. The efficiency at 600 m. from alternator output to antenna output is remarkably high for a tube system. No data are available on the efficiency of the tube alone, as ordinarily computed in terms of input to the plate and output in the antenna. It was impossible to adjust the coupling so as to obtain maximum output at the shorter wave lengths.

TRANSMISSION AND RECEPTION TESTS

If the signals from this transmitter are to be received by heterodyne methods, the emitted radiation is a close approximation to an undamped wave as far as the radiation characteristics are concerned. Consider, for purposes of discussion, that the amplitude of the output current from the tube is proportional to the plate voltage when the plate is positive. Then the antenna current will be of the form

$$I_a = I \sin \frac{\omega t}{K} \sin \omega t$$

PLAINTIFF'S EXHIBIT No. 19—Continued

for a half cycle and zero for the succeeding half cycle, ω being the angular frequency of the radio oscillations and $K=\frac{\omega}{2\pi F}$, the ratio of radio to audio frequency. The frequency components of the antenna radiation which are most effective in a tuned receiver are those to which the receiving antenna is resonant. Radio side frequencies or radio harmonics are effective to a smaller degree, depending, of course, upon their proximity to the fundamental or resonant frequency of the receiving circuit. Consequently, any radiating system is more effective, the greater the amount of energy radiated at a single frequency.

The modulated wave described above can be expressed as the difference between two radio frequencies

$$I_a = I/2\left[\cos\left(\frac{K-I}{K}\right)\omega t - \cos\left(\frac{K+I}{K}\right)\omega t\right]$$

which are separated by the slight fraction, $2/k$, of the radio-frequency. At 500 cycles and 600 m. this amounts to $\frac{1}{300}$ and as far as any ordinary receiving circuit is concerned the energy can be said to be radiated at a single frequency.

The logarithmically modulated wave trains radiated from a spark transmitter are emitted at an infinite number of radiofrequencies, the broadness of the emission curve being determined by the damping of the wave trains. Thus from the standpoint of the transmitter the power is radiated at a much smaller band of wave lengths from the tube transmitter than from a spark transmitter of equal power.

In substantiation of these statements the following tests are cited:

Signals from this set, which suplied 5 amperes rms, antenna current to an antenna approximately 50 feet high in Washington were copied at a distance of 100 miles by using an antenna 60 feet high, with an audibility of 10,000, using an autodyne receiving circuit with a two-step audio-frequency amplifier. Signals from this set working under the same conditions were received through heavy interference by using a 6-foot coil aerial and a similar detector and amplifier at a distance of 225 miles.

On the other hand, this type of modulated radiofrequency is not suited for reception with a simple nonoscillating detector. The voltages induced in a receiving antenna by a logarithmically modulated wave will give a response on the output side of the detector greater than that induced by a sinusoidally modulated wave train radiated from antennas in which the rms antenna current is the same, provided always that we confine our attention to short wave lengths.

PLAINTIFF'S EXHIBIT No. 19—Continued

The truth of this statement has been proven experimentally by direct comparison of two such transmitters. It is beyond the scope of the present paper to discuss quantitatively the effects of sinusoidally and logarithmically modulated wave trains upon receiving antenna with rectifier and phones. However, a possible reason for such a behavior is suggested by the accompanying diagram, Fig. 6, upon which are plotted *to the same* scale the envelopes of spark and sinusoidally modulated wave trains emitted by two transmitters operating at 500 cycles and supplying the same antenna with the same rms antenna

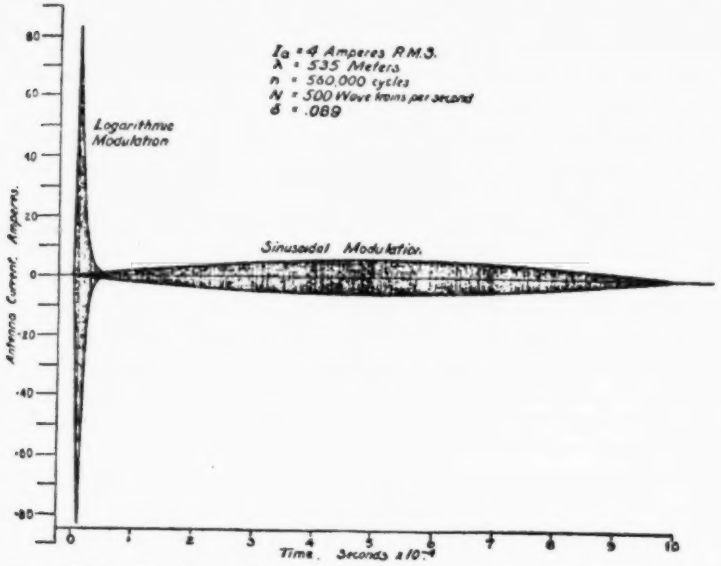


FIG. 6.—Comparison of wave trains from spark and tube transmitters

current. Although the logarithmically modulated wave train persists only about one-twelfth as long as the sinusoidally modulated wave train, yet it rises to a peak value over 13 times as great. In order to give some idea of their relative number of radiofrequency oscillations per cycle the vertical lines have been so spaced that each one represents a complete radiofrequency cycle.

It is not to be inferred from this diagram that the trains of voltage waves applied to the rectifier in a receiving circuit have an envelope precisely similar to the exponential envelope shown here for the wave train transmitted from the spark set. Nor should the assumption be made that diaphragms of the receiving telephones when acted upon by a strong voltage impulse lasting for one ten-

PLAINTIFF'S EXHIBIT NO. 19—Continued

thousandth of a second are distorted a proportionately greater amount than when acted upon by a weak impulse lasting for one-thousandth of a second. Undoubtedly, however, the voltage impacts acting upon the telephones are very much the more intense, though lasting for a shorter time, with the wave train of higher peak value, and it is possible that this is the correct explanation of the louder signal furnished by the logarithmically modulated wave train with simple rectifying detector. If the same power be radiated at long wave lengths, it is quite possible for the peak value of the logarithmically modulated wave trains to be so reduced in magnitude that the average value of their square (which is the measure of the output voltage of the detector) is equal to or even less than similar values for the sinusoidally modulated waves. It is likely also that if the wave lengths of transmission be sufficiently increased, the same results in receiving the signals with a rectifying detector can be obtained with the tube transmitter as with a similar spark transmitter.

In Fig. 7 are shown current-time curves of the actual output current in an antenna excited by the tube transmitter described above. These curves were obtained with a cathode-ray oscillograph in the following manner: Vertical deflections of the cathode beam were made proportional to the instantaneous antenna current by passing this current through suitable deflecting coils placed near the tube. Horizontal deflections were made proportional to the 500-cycle voltage by connecting the electrostatic deflection plates across the supply line.

By making a suitable adjustment of the phase of the deflecting voltage with respect to the radio-frequency wave train, it was thus possible to obtain a figure on the screen showing these oscillations throughout an audio-frequency half cycle, whose ordinates were proportional to the instantaneous antenna current and whose abscissæ were proportional to sine $(2\pi \times 500t)$. Those photographs were carefully developed to scale, making the abscissæ proportional to the time in seconds, as shown in Fig. 7. In copying the figures it was impossible to draw in the radio-frequency oscillations, so separate vertical lines are included, each to represent 15 complete radio-frequency cycles.

It can be seen that in actual practice the envelope of the antenna current is far from sinusoidal. Also the wave train persists with the damping of the antenna after the tube has ceased to supply power. It was found that a decrease in either plate voltage or

PLAINTIFF'S EXHIBIT No. 19—Continued

filament emission—that is, in power supplied to the antenna—resulted in a contraction of the peak on the latter half of the wave train; an increased emission from the filament, or closer coupling between the antenna and the plate circuit resulted in an increase in height of this peak without a corresponding increase in amplitude of the first group of oscillations. In no case was it possible to adjust the tube circuit so as to obtain maximum antenna current at the peak value of the supply voltage or approach more closely a sinusoidal envelope.

In summarizing the foregoing discussion the following essential points appear: (1) It has been found that an electron tube trans-

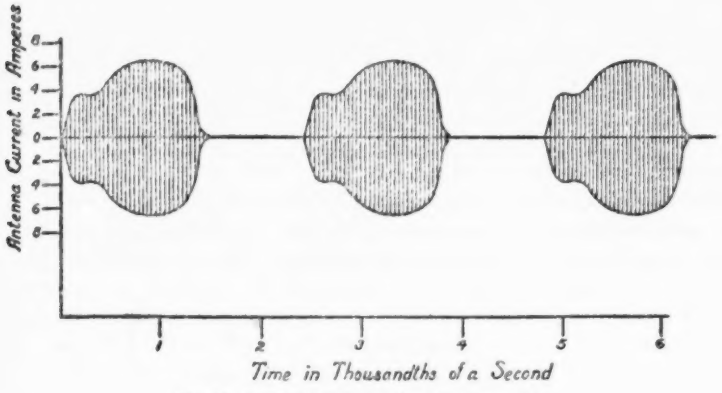


FIGURE 7.—Oscillograms of antenna current

mitter operated wholly from an alternating-current source can be made to compare favorably in operating efficiency with a similar transmitter operated from a direct-current source; (2) it possesses the advantage of not requiring a high-voltage generator or battery; (3) the added advantage over a continuous wave transmitter is that the signals may be received over a limited distance with a non-oscillating detector.

Most of the experimental work, the results of which are described in this paper, was performed by H. A. Snow of this bureau, to whom credit is also due for several unique features of design and construction.

WASHINGTON, *February 2, 1920.*

PLAINTIFF'S EXHIBIT No. 20

January 9, 1922

Work on the high frequency bridge will be continued. A satisfactory balancing of signals has been obtained and the actual measurement work will be tried to ascertain its accuracy.

Some amplifier work has been begun wherein the the batteries will be done away with, if possible, and the 60 cycle power utilized both for filaments and plates.

PLAINTIFF'S EXHIBIT No. 21

JANUARY 11, 1922.

Memorandum to Mr. LOWELL:

Since you say that you find it difficult to find details which can be mentioned in your outline of work for the week, I give you herewith a number of suggestions which will show the kind of things which it is valuable to put in an outline of this kind.

One point is that some details should be given of what has been done already, sufficient along this line to show how your plans tie in with the work already done. It is by no means adequate to say merely that a satisfactory balancing of signals has been obtained. This puts forward no results and allows no one but yourself to judge as to whether the balancing is satisfactory or as to whether your plans for improving the bridge and going on with the work are the best that can be followed. Particularly on this high-frequency bridge matter it is desirable to put down something about the work already done.

For what frequencies have your observations been made?

Was the input emf undamped, modulated, or damped? If not modulated, how and where in the output circuit is modulation introduced?

What is the source of power in the work you are doing and by what coupling is it applied to the bridge?

PLAINTIFF'S EXHIBIT No. 21—Continued

What detecting devices have been applied, with what results in each case, and what others do you expect to try, and by what particular scheme or connections?

Is the balance of the bridge sharp; that is, is the silent region narrow and can you think of any way of improving this?

Has any change been made in the ratio arms described by Zahn, which were condensers set at approximately the same capacity?

What types of apparatus constituted the unknown impedence and with what results? What additional ones do you contemplate trying?

Have any changes been made in the grounding and shielding, or do you see any way of improving this?

Please confer and cooperate with Mr. Cox continually in this work, as he has given considerable thought to this problem, as you know, his work being more particularly with the laboratory uses of the completed bridge in mind, while your work is more along the line of appiying your knowledge of amplifiers and receiving apparatus and other radio equipment to the functioning of the several parts of the bridge.

Now as to the work on the amplifier, the kind of detail which it would be desirable to give that would enable me or other persons in the bureau to judge whether the work is being directed along the best lines, is as follows:

What particular type of amplifier are you working on—audio or radio frequency?

How many types and functions of each type of coupling?

For what range of frequencies?

For what sort of use? This is important because of the possibility of a residual hum from the 60-cycle supply which might be serious to some work and unimportant to other kinds. How eliminate or reduce the hum?

What have you done already on this or similar amplifiers?

Over what range of frequencies have you made observations, if any?

In using 60-cycle supply, what, if any, rectification scheme is planned for the plate?

Give one or more wiring diagrams that you propose to try.

Wherein does this scheme differ from some known work, or what is the nearest thing to your proposed plan that has been done?

What tests do you propose to make of the amplifier's performance?

Please cease laboratory work until you have completed an outline giving at least as much detail as called for in the questions herewith.

(Sgd.) J. H. D.,

Chief, Radio Communication Section.

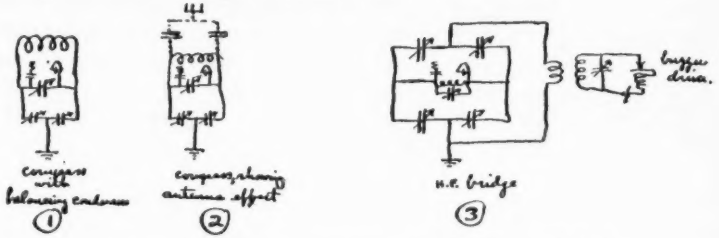
PLAINTIFF'S EXHIBIT NO. 22

January 12, 1922

Memorandum for Dr. Dellinger:-

In reference to the work on the high-frequency bridge:

It was thought that the principle of balancing out the antenna effect in a radio compass could be applied to the bridge, the following series of circuits showing the evolution from compass to bridge circuit.



As is shown in ③ a buzzer, (Kolster Decremeter), is used as source of input e.m.f. by coupling it into the bridge. Across the output is connected a coil and condenser and the grid and filament of a vacuum tube detector. Thus the bridge becomes a tuned circuit and must be tuned or nearly tuned to the source of e.m.f. Coupling into the detector circuit was also tried but with no improvement on the balancing although it is probably better to use coupled circuits. In using coupled circuits,

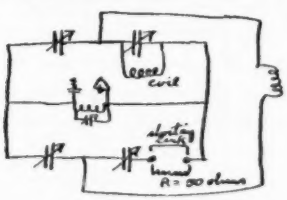
PLAINTIFF'S EXHIBIT No. 22—Continued

the output of the bridge is tuned with an ordinary coil and condenser, the coil being coupled to another ordinary coil and condenser circuit in the detector circuit.

Upon varying the condensers in the arms of the bridge, a very sharp and silent balance point is obtained, it being possible to set the balancing condensers to within $\frac{1}{10}$th of 1 degree easily. The coupling between the source of emf and the bridge input must be adjusted to give the best balance.

No change in the ratio arms as described by Zahn have been made nor has any change been made in the shielding system.

An ordinary pancake coil of about 100 turns has been placed in parallel with one of the balancing condensers and a resistance placed in and out of circuit in series with the condenser in the opposite arm as shown in sketch below.



Upon Mr. Cox's suggestion the R was connected in and out at various frequencies to determine the effect upon the balance.

PLAINTIFF'S EXHIBIT No. 22—Continued

It was found that with the resistance out and the short circuiting link in that the balance was perfect at all frequencies but with the resistance in, the balance was broad and did not fall to zero when the frequency of the input e.m.f. approached the natural frequency of the bridge.

This work will continue upon Mr. Cox's return to the Bureau as I am relying upon his suggestions as to the best procedure to be followed next.

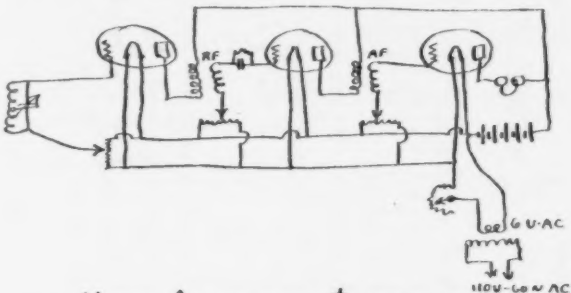
Regarding the amplifier work it was thought by Mr. Dunmore and myself that it would be very desirable to be able to do away with batteries in a vacuum tube circuit such as a multi-stage radio-audio frequency amplifier, where the filaments require a large storage battery and the plates need high voltage. If these could be eliminated and the filament and plate voltages be supplied by the ordinary 60 cycle 110 volt lighting circuit. Nothing has been done on this problem heretofore, so to my knowledge. Its advantages are obvious; the expense of purchasing and upkeeping batteries would be eliminated and as well as the transporting of heavy batteries where the set is to be moved from place to place, the 60 ~ voltage being available practically everywhere.

It will be attempted to work any combination of radio and audio frequency stages and valve detectors by balancing out the 60 cycle hum with grid voltage ~~potentiometers~~ or by other means.

PLAINTIFF'S EXHIBIT No. 22—Continued

It may be possible to make a rectifier so that any existing amplifiers can be run on the 60 cy A.C.

For the plate voltage, if a small tube rectifier will be tried, a transformer supplying from 40 to 200 volts being used, this voltage being rectified and smoothed out with impedances and condensers. A similar scheme will be tried for the filament voltage although it may be possible to apply 6 volts A.C. directly to the filaments without rectification and keeping the grid voltage at zero with a biasing rheostat or stabilizer as shown below.



It may be necessary to use a crystal detector as it is not known what effect the A.C. will have on a tube detector.

The circuit shows 1 radio-frequency stage which can be made for any desired wave length or band of wavelengths and 1 audio-frequency stage.

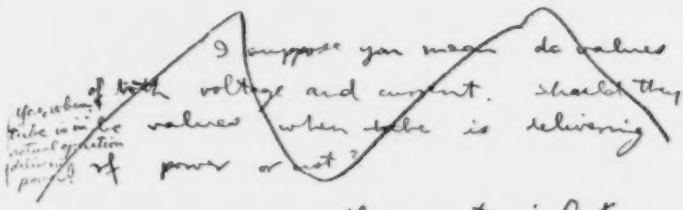
The construction of the R.F. transformers is explained in my report – CR 342-f.

Respectfully submitted
P. D. Lowell

PLAINTIFF'S EXHIBIT NO. 23

PDL

1-13-22?



Your outline report is O. K.

Please refer to your copy of lab. report, "Radio Terminology", for expressions "electron tube" instead of "vacuum tube", and "voltage divide" " " "potentiometer".

Have you begun the work on the smoothing unit circuits for use with rectifiers? Will not this be the principal part of the job? Pennington told a good deal on this subject, and I believe it has been treated in publications by others.

Have not tried any rectifier circuits yet. Think that rectifier plate voltage will not be reduced as much as amount of some d.c. voltage which directly affects the grid voltage. Will look up Pennington's dope as well as others. JHD

Apl 4 to apl 9, '21. F. W. Dunmore

Apl 4 Cleaned up work on syn. 500 gap construction. Also made effort to get a truck. Wrote up legions for pictures in O F paper

Apl 5 Tended to misc details. Worked with Sowell tuning up ~~varied~~ loops using quenched gap.

Apl 6 Prof. read OF paper & got photos & ~~pe~~ tracings together etc. Worked A-T transmission tests using quenched gap. ~~Ca~~ At Kensington & moving half mile sigs changed from equality to 1/double other. Seems good advice.

Apl 7 Worked on D.F. ~~cases~~ paper & got a letter & pictures abt it off to F.A.K. Talked over Coast guard telphon problem with N.S.S. 4.E.M. & St. Returned loop transmitter

Apl 8 Talked with Capt Vaughn of Dayton regarding the aerial navigation program.

Apl 9 Worked on O F specification. Worked wrung up synchronous gap set. Sent ~~on~~ on ~~-~~ uni-directional set for tests got good results above Kensington. Unidirectional point ~~turns~~ turns thru the ~~just 4 deg~~ 4 deg

PLAINTIFF'S EXHIBIT No. 24—Continued

Aug 1 to Aug 6 21 F. W. Dunmore

Aug 1 On leave
" 2 " "
" 3 " "
" 4 Worked on D.F. material with Guld. for P.U.R.C. Outlined work for Engle & Bernard until my return
" 5 on leave
" 6 " "

Aug 8 to 13. W. F. W. Dunmore.

Aug 8. On leave
Aug 9 " "
Aug 10. Talked over reorginegation of work with L.E.W. Went over coil aerial dope Field wrote up for Purc.
Aug 11. Got together quotations for complete radio beacon set for Tuffer. Read dope on remote control via radio, secret systems etc.
Aug 12. Talked with Tuffer regarding above quotations. Talked with Eckhardt regarding tube relay. Worked out circuit for use of carrier after 3 stages of amt radio amplification.
Aug 13 Got apparatus together for set-up for recording sigs. Attended group chief meeting.

Aug 15 to 20 1921 F. W. Dunmore

Aug 15. Worked on set up for recording sigs. Tended to ordering more prints etc for DF specifications.

Aug 16 Worked on recorder problem. Tried various sz coils, "B" bat potential etc, to ~~[illegible]~~ get set to work.

Aug 17. Worked on recorder problem. & Took Mr Mc Donald of Australia around the B Wharf. Answered letters.

Aug 18. Set up new recorder circuit with amplifier. Wrote letters & to go to, Cleaned up my desk & room. Sugarding bracon characteristics

Aug 19 Found needed more negative C battery to make recorder tube critical at oscillating point. Took half day. leave.

Aug 20. Collected data on Tulip's calibrations (RC) & put same in tabular form for comparison. Attended groups chief meeting

Aug 22 to Aug 27. 21. F. W. Dunmore

Aug 22. Finished up calibration data collection. Looked up dope on quenched gaps & wrote Balto-Lighthouse dispat regarding it. Added dope to D.F. Terminology

Aug 23. Read D F dope in Radio Review & The Electrician. Went over Yatis DF drawings. Worked on electron tube relay circuit.

Aug 24. Went over Yatis D.F. specifications & wrote him letter advising some changes in electrical features. Worked on electron relay recorder. Went downtown & saw Tuffer regarding beacon synchronization.

Aug 25. Wrote letter to commissioner regarding beacon synchronizing. Answered an inquiry regarding radio compass specification.

F W Dunmore Aug 29 to Sept 3 21

An annual leave all week (special)

F. W. Dunmore Sept. 5 to 10. '21

Sept. 5 Holiday

" 6 Wrote several letters regarding D.F. specifications etc. Worked on ~~test~~ tube relay circuit. Got relay to operate on sigs that gave 0 to 20 milliamps deflection

Sept 7. Went to N.Y. & attended I.R.E. meeting on Hopul recorder.

Sept 8. Spent day at Lighthouse Depot N.Y. having alterations made on ambrose lightship beacon & talking with mr yates regarding beacons & compass

Sept 9. Talked with engineer aboard Ambrose regarding operation of beacon & capt of Tulip regarding compass on Tulip. Tested out radio compass & checked up beacon intervals

Sept 10 Took half day leave.

Sept 10 to 15 21. F.W. Dunmore

Sept 10. Worked on recorder getting audio howl out of it. Set up loop circuit for receiving undamped with detector & 2 audio stages. Tried audio tuning of audio stages.

Sept 11. Worked on recorder. Put grid leak across secondary of input transformer to stop howling.
Went down to see Tupper regarding lighthouse Superintendents conference for which we are to have an exhibit.

Sept 12 Attended group chiefs meeting. Worked recorder at in shaking machine. 4" coil.
~~Talked with~~ Drew up curve for Wavelength Turns for 50 & 36.30 metres

Sept 13. Wrote 2 letters & sent out DF dope Talked with LEW regarding Dept L Houses exhibit.

Sept 14 Worked on ~~DF paper~~ Coil Antenna paper. Tended to misc items. Started to set up models for Lighthouse Superintendent meeting

Sept 15 Finished setting up " " " "
Worked on coil Antenna paper

Sept 12 to 17 21 J W Dunmore

Sept 12. Wrote report of trip to n.y. made out travel blank.
Talked with L.E.W. regarding radio compass specifications

Sept 13, Revised list of Co's to whom D.F. specs have been sent.
Looked up all dope on recorders in the library.

Sept . 14 Talked over work at Dayton with L.E.W. Wrote letter to Commissioner.
Wrote Lab. report on a Simple Type of DF for use on Shipboard.
Sept 15. Worked on radio recorder. Finished report on Simple D.F. for ship use.
Attended meeting in office.
Sept 16 Worked on recorder. Got 0-40 milliamps change for modiate strength
Sig. Visited naval Observatory & found em using recorder like mine.
Sept 17 Connected recorder to antenna & got NAH & NAI & NSD & to operate it
Wrote Letters.

PLAINTIFF'S EXHIBIT No. 24—Continued

Sept 19 to 24 '21 F W Dunmore

Sept 19 Rewound relay to ~~4000~~ 12000 turns no 28 S.S. enamel. 1400 Ω. Designed loop to wind with various turns to get λ ranges

S. " ✓ 20 Adjusted recorder using outside aerial & experimented with new relay. Bad defl on recorder. Wound loop for picture to show simple loop.

" 21 Talked with λ & radio inspector regarding WHB & RM. Showed a friend of LEW's around Bureau. Tried out new circuits on recorder.

" " ✓ 22 Got apparatus set up & had picture taken of simple loop & set. Got apparatus together to get design of case for recorder. Designed same.

" " ✓ 23 Worked on relay circuit. Got loop & apparatus hooked up to make wavelength-turn data.

" ✓ 24 Assembled recorder on base & wired same up & got it to operating satisfactorily.

Sept 26 to Oct 1 '21. J W Dunmore.

Sept 26. Went down on northland & had picture taken of simple DF & operator. Worked on relay. Found that weight on armature stopped static from relay. Wrote letter to Yatio giving him specifications for beacon transmitter

Sept 27 Worked on relay mounting same on base. made up variable loop C. latticy

Sept 28 mounted relay on bases put in base former to operate filament on A.C. Worked 8 hr. attended meeting of J H D on trip to Europe

Sept 29 Worked on relay, fixed same up with plug etc to operate by plugging into any fone plug or receiving set. Went over report on a Simple DF for use on Shipboard with Budd & got it ready to publish in the Radio Service Bulletin.

Sept 30. Proof read above report again. made up list of projects for me to do for B. of Lighthouses & list of exibits. Wrote monthly report

Oct 3 to 8 1921 F.W. Dunmore

Oct 3! measured λ o on 4' loop for 1 to 20 turns. Wirkadon recdr circuit.

Oct 4✓ Scrolled & worked on recorder circuit & he got strength of audio tuning etc. of transformer. I had lumen relay coil but didn't have enuf C. He tried it with more C & worked fine. Wirkson rather weak sig now with right and/or note.

Oct 5✓ Worked on 4' coil get λ dope for diffnt turns. Experimented with recorder can tune to audio note fine & eliminate a R.M. get Bordeaux, O.K.

Oct 6✓ Worked with recorder & wound 240 turns on 4' coil & measured to λ o with diff. C's. & Proved Eckhardt the Recorder.

Oct 7 Worked on curves of λ-turns on 4' coil. Cleared out incoming tray. Talked with ~~Eaton~~ Cox & told him how to get standard λ by getting tube going at audio frequency & a generator & adjusting to no beat note then start another tube at any harmonic of 1st one & receive on detector & get beat note when hit right λ.

~~Oct 8~~

" 8 Drew up curve of λ-turns from data on 4 ft coil

Oct 9

F.W. Dunmore Oct 17 to 22, 21

Oct 17 ✓ Went to various sections of the Bureau & got up a program of exhibits for Lighthouse Superintendents visit here tomorrow P Started report re – A Relay For Remote Control by Radio.

Oct 18 ✓ Worked on " "

Showed Lighthouse Superintendents around.

Oct 19 Attended group conference meeting. Looked up dope for Penn State College.

Oct 20 ✓ Determined speed of operation of recorder Fixed up some set & gave concert for Edgerton. Read re Victrola Catalogue

Oct 21 ✓ Worked on report re recorder. made some tests re same. Talked with mr W.O. Coughlin OF man from Navy Yard Phila.

Oct 22 ✓ Worked on recorder report. Designed panel to hold recorder apparatus Tried out further audio tuning tests on recorder.

F. W. Dunmore Oct 24 to 29 '21

Oct. 24 Went down to signal corps to see Bruce Relay in operation. Went over picture proofs of DF paper. Worked on design of recorder panel

Oct 25 Worked on design of records panel. Wrote letters to Bof L. Amrad & Federal Co

Gave talks on recorder. Proof read DF picture titles

Oct. 26. Attended group chief meeting. Made comparison of Federal & C & I audio transformers and recording. Wrote letters.

Wrote Sealed up dope & wrote letter to Bof L. regarding receivers & beacons for lighthouses

Oct. 27. Made measurements of input voltage & signalling plate current & on radio recorders under various conditions. Worked on recorder report.

Oct. 28 Talked with W a Miller regarding recorder. Wrote letters Gave Winters some dope

Oct 29 Worked on audibility measuring set for LEW to take to N Y.

Oct 31 to nov 5 21. F. W Dunmore

Oct 31. Worked all day making an andhisty cit up for LE W to take to NY to measure decrement etc on Simons vane (W 1163).

~~Oct~~ Nov 1. ✓ Wrote monthly report, finished report on radio receiving relay.

nov 2 Wrote letter to Ferry boat Co in San Francisco & gave him dope for putting DF on Ferrys. ~~Wrote~~ Started report on relative merits & demerits of DF as installed on land & on ship.

nov 3 Spent day getting equipment in shape & together to send up to Atlantic city to conduct Coast guard phone tests

nov 4 Worked all day packing up radio phone apparatus to send to Atlantic city for Coast guard phone tests

nov 5 Talked on trip & tests to be made at Atlantic City. Worked on Daniels short wave amplifier & got same ready to take.

F. W. Dunmore nov 7 to 12 21. F. W. Dunmore

nov 7. Went to Atlantic City (→ to conduct radio phone tests on US coast guard life boat) got apparatus unpacked & land phone station installed

nov 8. Prepared Sum amplifier & phone set. Wound 2 turn loop on boat (36' long) Put on batteries & phone set. Loops ran each side of boat ⟹ & keel.

nov 9. Tried out phone set on boat, & had open in phone set which we fixed Got 1 range of 2 turn loop with condenser 25453-D. Also fixed squeaky generator

nov 10 With 1 turn vertical loop 36 strands copper on keel & side, got .7 amps at 350 meters Wire had 1/4" heavy rubber insulation. With one turn of Litz 98 strands & 78 got .5 amps at 350 m. Got 7 ranges of 1 turn with condenser 25453-D

nov 11 Holiday.

nov 12 Turned up Land set for 670 & 349 m. Located & found trouble in phone set made test up to 2 miles (trying combination 2 pull wire loop & wire & keel loop. Keel about as good. Need 675 m at land, sending & 350 sending from boat

F W Dunmore nov 13 to 19. '21.

Sunday nov 13. Went to church in A.M. Put 2 more loops on boat. Ans full turn on of heavy insulated wire which Whittemore brought. Also two loops in parallel connected to the fuel Also put in an under water antenna

nov 14 made a bunch of tests up to 5 miles trying all combinations of the 2 loops Found single turn either heavy fuel or not at 350 m to be best. Got minimum as I cut turned but it is so sharp that it don't bother

nov 15 got sets all dolled up for demonstration, & fired 1 or 2 troubles made a 5 mile test out to sea & everything working OK. ~~Expect~~

nov 16 guard took Superintendents out and gave em a demonstration, everything OK & we worked up to 6 miles. All were pleased. Packed stuff up & returned to Washington

nov 17 Went over bunch of letters on incoming list

nov 18 Wrote up expense account & weekly report cards. Went over rope from yatch (Bureau of Standards)

nov 19 Started wiring up the Receiving Recorder which is complete except for wiring.

FW Dunmore Nov 21 to 26, '21.

Nov. 21. Answered letters. Started report on Telephone Tests on Life boat at Atlantic Cty. Revised article on Simple Type of S.F. for publication in the radio news.

Nov 22 Answered letters. Worked with Engle wiring up recorder. Got it finished took it down in navy Lab & hooked it on to a printing telegraph & NSF wrote to us by radio. Worked great

Nov 23. Worked recorder again for further demonstrations of the radio typewriter before navy officials. Wrote up dope on radio phone tests on life boat for Radio Service Bulletin

nov 24 Holiday.

nov 25 On annual leave

Nov. 26. Read recorder dope in Wireless World. Put ~~in~~ transformer in recorder so as to light filaments from 60 ~. Also did other work on it. Went over report of radio phone tests, for associated press.

nov 28 to Dec 3 '21 F W Dunmore.

nov 28. Connected up C.W. 7000 meter tuner & recorder & tried out combination found I could get best recording with set oscillating. made plug leads etc for use with recorder

nov 29 Worked on radio phone coast guard report and relay recorder

nov 30 Out on leave

Dec 1. Worked on report on radio phone tests in coast guard boat.

Dec 2 Tried 150 D.C. generator on recorder as plate voltage. Had smoothing out inductance & capacity. Found it worked ok. Talked with Duncan regarding use of rectifier tubes to get plate voltage for recorder.

Dec 3. Spent morning & part of afternoon putting permanent set-ups in 20 3 in working order. Worked out circuit to get grid & plate voltage for 4

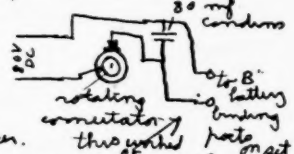
42

Dec 5 to 10. 21 — F W Dunmore

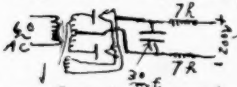
Dec 5 — Tried audio turning on 2 stages of audio amplifier & found it worked ok Went down to Gen Service & Patent Section & regarding patent on Receiving Relay.

Dec 6. Wrote up dope re patent on relay. Set up audio amplifier with tuned audio stages & got very good selectivity. Put condenser on permanent set up to tune it to the audio note of recorder.

Dec 7 — Tried method of getting plate voltage for receiving from 60~AC. Could use a synchronous motor & charge condenser on the + humps of AC wave by a contactor on wheel & thus charge condenser.



Dec 8 — Set up a receiving tube double wave rectifier to get 200 V DC from 60~110 AC. used this circuit & it worked fine on 6 tube amplifier as plate voltage.



worked recorder fine or with a resistance across output to make voltage drop to 80 V it worked on 6 tube amplifier fine

Dec 9. Set up a double wave tungar rectifier with big smoothing reactance & got DC to light receiving tube filaments from AC. Sa not look. made photo tests with P & A dept.

Dec 10 — made up list of proposed work, Set up a detector & 2 stages of audio with filaments on AC. Used stabilizer with center tapped going to grid. Also used C battery got rid of most of hum.

FWD umnon Dec 12 to 17 21

Dec 12. Spent all morning on recorder patent with Mr Prescott Sawyer. Talked with Bell Co re radio DF. work

Dec 13 Worked on AC transformer to give both filament & plate current supply to operate tubes in recorder.

Dec 14. Wrote monthly report. Read galley proof on DF paper

Dec 15 Worked on transformers to give 3, 6 volt and AC supply circuits from 110 AC & one 300 volt & one 70 volt. This was finished & connected up to recorder & it worked OK using the rectified AC for plate voltage & the AC on tube filaments. made radio phone test with P.O. & talked about it with Edgerton

Dec. 16 Succeeded in getting the "C" battery voltage for the grid from the AC line also. so that the A, B & C battery power are now obtained from the AC line. Went down to patent office regarding changes on govt patent application I filed year ago

Dec 17 made further tests on recorder. Got apparatus together for building a new recorder to be worked entirely from the 110 V AC line.

Dec 19 to Dec 24 '24. — W D [illegible]

Dec 19 Got equipment together for a new recorder to be worked entirely from the AC line. Started lay-out of new recorder.

Dec 20 modified potafone for 2no 350 & 2500. in order that P.S. may make radio phone demonstration. Went down to the P.S. radio phone station & talked with Edgerton regarding.

Dec 21 made tests on recorder using new type recording device. Succeeded in recording message from POZ claimed up R. 203. Started revised report on recorder

Dec 22. Finished revision of recorder & drew up a new circuit diagram for same started tracing it.

Dec 23. Finished tracing above diagram & traced 3 others to send away with recorder report for publication of same.

Dec 24 Got recorder report ready for publication in the Journal of The A I E E
Worked on lay-out of apparatus for new recorder.

PLAINTIFF'S EXHIBIT No. 24—Continued

7 W D ~~~~~ Dec 26 to 31 '21

Dec 26 Holiday

Dec 27 ✓ Worked on lay-out of new recorder. Answered letters

Dec 28 ✓ Used old recorder up to with the new tape register for demonstration / use including the day all for operating the register with the recorder

Dec 29. Worked on new recorder

Dec 30 ✓. Continued work on recorder. Read radio magazines. Got report on recorder three finally into the outgoing mail.

Dec 31. Showed visitors around radio bldg Experimented with a high speed type of relay for use with recorder. Half holiday

F. W. Dunmore Jan 2 to 7. 22

Jan 2. Holiday

Jan 3. Completed lay-out of panel for type B recorder & got work started on same in shop

Jan 4. Had new drawing made of recorder circuit & for supports for ~~panel~~ apparatus in new recorder. & hound visitors about Lab.

Jan 5. Read proof on DF paper. Got new mechanic started on recorder. Worked recorder on POZ at 30 W.D.S. per min. made tests (satisfactory) with it on Radio Central at 40 wds per min

Jan 6. Tried out limiting effect of a tube with low filament current. Studied Wembingo papers on recorders. Answered letters.

Jan 7. Cleaned up protractions on relays & recorders & worked on recorder in shop. Wrote letter to Virgil Kaesburg re selective receiving circuit using 3 or more transmitters of radio frequency different λ's & 3 or more receivers (each) tuned to the different λ's & 3 or more recorders each on the receiver, the (3 or more) recorder relays (to be) in series. (The 3 or more λ's must be received at once.)

Jan 9 to 14 '22. 7 W D ~~~~

Jan 9 Cleaned up pictures prints etc for Coast Guard & Records reports. Got wire in aggregate together for recorder.

Jan 10 made up a set of seven 000025 mf fixed condensers (compact type) for the audio tuning in the Type B recorder. Answered letters.

Jan 11 Worked on construction of Type B recorder made up a transformer to ~~Jan 12~~ give filament current, plate voltage & grid voltage from the 60~ line.

Jan 12 Set up new transformer & tested same out before putting on last 2 coils. Got drop of 30 volts in plate circuit when signal came in. This is not objectional Talked with Capt Walton of Coast Guard regarding radio telephony

Jan 13 made out proposed schedule & work for Air Service. Drew up brackets etc for mechanic brackets needed for mounting apparatus contained in Type B recorder

Jan 14 Wrote monthly report. Finished winding new transformer. Answered letters.

Jan 16 to 21, '22 7 W D unmore.

Jan 16. Made up a further list of proposed work on air Service projects

Jan 17. Worked on list of people to send DF papers to. Wound 2, 8 volt windings on transformer. Mounted Kuhlhell plug on recorder & cut hole in box so as to plug 110 AC on recorder. Also mounted 6 binding posts so that if necessary recorder may be used on battery supply. Took in hours leave

Jan 18. Sent radio music for 4 Signal Corps Jans mechanic instruction on making up supports for apparatus on Type B recorder. Answered letters. Started winding on new relay

Jan 19. Jan 20. Wound Marburn type B-1 relay with 16,000 turns of no 38. connected it into recorder circuit & made a few tests.

Jan 20. Jan 21. Made comparison tests on Marburn relay and the ordinary relay as now used on recorder. The Marburn relay is superior to some extent due to the better mechanical construction but was not very much more sensitive. Went over in machine shop & followed up work on Type B recorder

Jan 21. Jan 22. Tried out new relay on speed work. Operated it 50 wds per min OK. Also got an idea for transmitting 3 or more messages on one wavelength by using Type A or B recorder - See note book for details

F. W. Dunmore Jan 23 to 28, '27

Jan 23. Worked with mechanic on relay. Set up 2 choppers in parallel & sent 2 messages on different audio notes.

Jan 24. made phone tests with P. O. Dept. They were using their telephone stunt.

Jan 25 Received new Bunnell relay. Rewound same with 2 2,000. Turns no 38. & made test. It is somewhat more sensitive on weak signals than the one now used & has much more "pep" on ~~the~~ with the average signal strength

Jan 26. Wrote letters. Worked with mechanic putting finishing touches on type relay. made lay out for new Bunnell relay on same. Worked on 2 note audio freq. tube generator for duplex ~~the~~ radio telegraphy. Took ½ hrs exam

Jan 27. Worked on Diplex receiving set and sending circuit. Connected 2 audio tube generators to input of radio phone & modulated ~~as~~ radio wave at 2 audio notes. Rec'd these on one λ & was made either work a relay at will thru the tuned records circuits. Worked it same as tho I had 2 relay records each working on a different note & receiving its respective msg

Jan 28 Worked on Type B recorder wiring up same

F. W. Dunmore Jan 30 to Feb 4' 22.

Jan 30 Worked all day wiring up "type B" recorder. Talked with Sowell regarding A.C. receiver.

Jan 31 Worked all day wiring up type "B" recorder.

Feb 1 Completed wiring of recorder but found I had a poor tube socket so changed it. made test on recorder & it worked fine. Worked entirely on A.C. Adjusted buzzer to give good note. Also operated A.C. made type B recorder register one signal in tape & the type A another both at same time & with set tuned to one λ. but got 2 stations each on a different note.

Feb 2 Cleaned up R 203. Demonstrated new recorder to Archer. Made more reports on it. ordered

Feb 3 Worked recorder at once on NSS one recorded two spaces wave, the other the sending wave Tested out new recorder to see if it could operated on batteries OK & it did. Also had a cover for same drawn up. Talked with Sowell regarding design of new A.C receiving set & amplifier. ~~Succeeded in recording~~

Feb 4. Took recorder equipment to 3XF & tried to receive two msgs from NWY on same antenna Worked NWY phone set & modulated it with 3 audio notes. Was able to record a few letters on 1 note other on the other simultaneously

Feb 6 to Feb 11. '23 F W Dunmore

Feb 6. Gave navy demonstration of type A & B recorder as they have asked officially to submit a report on it. Worked on method of modulating phone set with 2 audio tube generators & without ~~the~~ one tube changing the note of the other. Found that two modulator tubes would do the work.

Feb 7. Hooked up two modulator tubes but as yet have not gotten 2nd tube to modulate correctly. Got Attended meeting. Talked with Lt Walton regarding radio phone sets for life boats

Feb 8. Attended group chief meeting all morning. Made out list of material needed for short wave set. Attended another meeting on broadcasting wavelengths.

Feb 9. made further tests on modulating at 2 different audio frequencies. Was unable to get second tube to modulate OK. Had carpenter make up spacer spreader for 15 turn 3" coil. Attended meeting on broadcasting Loop (turns in parallel). Got HV Gen on 202 connected up as a start on short wave transmission

Feb 10. Drilled a bunch of wooden spreaders for new short wave coil aerial transmitter & worked out method of putting up same. Attended meeting in 21 Z.

Feb 11. Wrote report on a Visual Records & method of Visual Signaling & its use on airplanes. Drilled more spreaders. Showed an English Engineer about the bldg. Read over PD Lo report on ~~of~~ C amplifier

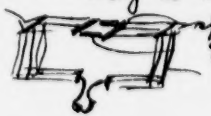
Feb 13 to 18 '22. F. W. Dunmore.

Feb. 13. made list of material to buy for short wave air service project & had bids sent
Worked further on 2 note modulation. Can't get 2 modulator tubes to function but 1 using a note to actuate can get em both pure
Feb 14 Wrote letter to Tug Boat Co re D.F.'s for use on Tugs. Wrote monthly report.
Feb 15 Put new B batteries in Type A recorder & fixed fine "C" voltage adjustment.
Got apparatus together for phone set for Director. Took some leave.

Feb 16. Got tape record of 185 & 180 spacer wave by the use of Type A & B recorder. Wrote up an idea of remote control by radio using 2 crossed coils on slightly different λ's & getting 2 audio heterodyne notes each of which work a relay, the relay coil of each recorder operating on a single armature so if sig intensity from 2 coils is equal the arm is pulled equally in both directions & don't move. If one gets stronger sig than other it goes to Rt & Left & so may work rudder to R or L. Put phone set in at Dalhart & Nichs
Feb 17. Got recorder in shape & took it down to A.R.R.L. convention. Attended talks at it & gave one
Feb 18. Wrote up another idea of a direct reading self turning D.F. It is this. Use 2 crossed coils with switches to throw first 1 receiver & recorder on to 1 coil then another receiver & recorder on to the other coil. Each receiver has 1 relay coil the 2 coils operating successively on 1 armature. As switches are spotted rapidly the armature vibrates between 2 contacts if coils are set on equisignal line. If not armature stays over on 1 contact & operates motor to turn coil.

Feb 20 to 25 22. F. W. Dunmore

Feb 20. Wrote letters re-DF specs. Got tubes & filled up an empty 1105-B & got it working.
Wound & set up 2 small loops to try out method of keeping a ship or plane on a given line.
Feb 21. On annual leave
Feb 22 Holiday
Feb 23. made up a 21 wire 50 ft loop all wires in parallel. Got same all ready to string up over DF shack. Wires spaced 3" spreader condenser in top thus



Feb 24 Worked all day on write-up of relative advantages & disadvantages of DF's installed on shore & on shipboard.
Feb 25. Completed erection of above loop. Finished above write-up

Feb 27 to mch 5. 22. J W Dunmore

Feb 27. Answered letters. Bought lead-in to shack from new loop. Tested same out for λ & found it to be exactly 100 metres. ~~+ ½~~"

Feb 28 Spend morning making out list of equipment needed & from whome to get it. Put up H.V. line from radio bldg to shack for ~~future~~ 100 metre transmitter. Attended broadcast conference.

Mch 1. Went down & got ~~door~~ Tirrel to put ~~on~~ good write-up on Radio Engineering on DF paper. Set up 100 metre tuner set & worked on it trying to get it to perculate.

Mch 2. Rewrote letter to Navy giving them estimate on cost of 2 relays. Took 6 pictures of 100 metre loop. Worked on 100 metre tube generator to get low resistance loop as possible, got 15 amps in a ¼ square copper strip loop.

Mch 3 Went over part of paper on relative advantages of two DF systems & AC amplifier report with Gould. Took short wave generator down in shack

Mch 4. Worked up magnetic & mounted same on base with 3 switches for throwing either to phones or magnetic. Also for throwing from antenna to loop, & a fil switch, ~~to shack~~ all for Bellaston W. Worked some more going over DF advantages & system.

mch 6 to 11, '22 F. W. Dunmore

mch 6. Worked on 100 meter coil aerial transmitter. Took dimensions & data on it & put in note book. Tried various tube circuits & grid & plate turns. Got 2 amps in loop with one type G W.E. tube

mch 7 Took magneto etc down to Directors office & fixed it up on the set & put him up a 3 turn to recorder paper for A.I.E.E. & coil aerial with switch to use either it or antenna. Got my transportation to N.Y. to Celebrate Tulip Wrote abstract paper

mch 8 Answered letters. Proof read abstract of my recorder paper & P.D.L. A.C. amplifier tube Witnessed competitive tests by navy of my relay & a Bruce relay. Doped out circuits to try on 100 meter coil aerial & will try em when weather gets warmer

mch 9. Went to N.Y. on Bureau of Lighthouse transportation. Attended radio convention

mch 10 Talked over D.F. & beacon work with yates.

mch 11 Went out on Tulip to Celebrate but ~~weather~~ the weather was so thick that ~~Celebrated DF on Tulip~~ couldn't get right shots on Ambrose.

mch 13 to 18 22. F. W. Dunmore

mch 13. Went out on Tulip & got 2 good calibrations. no changes over 3°

mch 14. Cleaned out incoming tray. Went over Telephone Conference Report.

mch 15. Revised report on advantages of D.F. on ships & ship. Attended 2 meetings

mch 16. Wrote monthly report. Wrote letters. Looked over radio & sound report. Went down to Bureau of Lighthouses to tell em alcrit Tulip calibration.

mch 17. Answered letters & Cleaned up 203. Got both recorders working OK and made demonstration to visitors. Drew up a "G" tube socket for machinist.

mch 18 made up a trimmer tube circuit with proper coils for use with 4 G tubes on 100 meter coil transmitter.

Mch 20 to 25 '22. F. W. Dunmore

Mch 20. ✓ Wrote up abstract of recorder report for radio service Bulletin. Completed oscillation transformer for 100 meter transmitter.

Mch 22 Connected up new oscillation transformer on to 100 meter coil circuit & found couple of engineers around moved high voltage generator from 202 to 203 & rewired same to power & lineate shacks.

Mch 23 Worked on 100 meter transmitter getting best turns for 100 meters on new oscillation transformer 3 used up D F permanent set up in 203 Attended group chief meeting. Wrote up direct reading self rolling DF idea in note book.

Mch 24. Proof read D.F paper circular 428 which came out today. Tested out the 4 G. tubes rec'd from Dayton & found 2 burn. Got 25 amps (1200 milliamp on plate & 3 amps fil)) in antenna with good one at 100 meters.

Mch 25 Worked on 100 meter transmitter to get a good modulator. Found a chopper in fil. connection to oscillating circuit to be tried. Wrote letter to C.I.E.E. telling I could'nt present my paper on the recorder.

Mch 26 Worked on short wave transmitter. Got 3 amps at 105 meters, chopped using on 50 W WE type G tube. 700 Volts on plate 3.2 fil amps. made numerous additions to report on relative advantages of loading the DF on ship & on coral ship

Mch 27 to April 1. 22. J W Dunmore

Mch 27. Proof read second paper on method of constructing simple receiving set. made up balancing transformer for DF installation on a Tender Columbine. Instructed Mr Bedford from Navy Lighthouse Depot on beacon & DF work.

Mch 28. made new secondary for 100 meter transmitter so as to be able to vary coupling. Put same in place of old one returned. Instructed Bedford further on fog signal depot

Mch 29. Went early out to Kensington (15 miles from Washington) & received 100 meter transmitter on 3 turn 4' coil with non oscillating detector 2 stages audio. Used 3 amps in transmitting loop. Worked on a receiving circuit to oscillate on 100 meters. No results yet

Mch 30 Worked on radio frequency amplification at 100 meters. Tried air core & iron core transformers. Found air core coil best but sharp.

Mch 31 Went over Wireless Improvement Co's DF apparatus in detail and told Mr Bender what I needed to calibrate the DF on the Cambria. Wrote letter to Hiram Putnam

April 1. Got material together to make a 100 meter 4 stage amplifier. Talked with Dunmore re equipment needed to calibrate the DF on the Cambria made some tests at home in the evening on reception of sigs over AC line using AC amplifier

April 3 to Apl 8 '27

April 3. Spent the morning working on the permanent - set-up relay recorders as they were not working properly. Started wiring up a 3 stage 100 meter amplifier for Air Service work. Talked with Toffer re- beacons on buoys.

April 4 Worked further on 100 meter amplifier. made one consisting of 2 stages of Cote coil coupling with a variable coupling between coils for radio frequency amplification and a detector & 2 of audio.

Apl. 5. Tended to minor details, DF paper list, apparatus to take to N.Y. Put new Tuska calibration on tracing Transport Listened for W.C.I. to make λ measurements. Got material together to Calibrate Cambrai

Apl 6 Got material together to send to Gatty for the local beacon tests. Wrote up schedule of my work Listened in on Cape May & made λ measurement. Went to N.Y. to Calibrate DF on Cambrai

Apl 7 Connected up new amplifier & got everything ready for DF calibration on Cambrai

Apl 8 made calibration of DF on Transport Cambrai

FWD memo April 10 to 15. 22

April 10. Got LC 56 in way to Republished. Dfed up schedule & method of measuring WCF. 2 made λ & audibility measurements on WCF at Chg Chase all afternoon

April 11 Put strap on type B recorder. Got mechanic going on tube sockets for short wave work. Gave talk at section meeting

April 12 Wrote report on Cambrai Calibration tests. Put strap on Type A recorder. Wrote many letters. Worked on working drawings of recorder with B Ackeley. Attended meeting. Dfed up short wave antenna where it needed repairs.

April 13 Took 100 meter amplifier down in shack & set it up for recvg from onrad. Put up a 1 wire antenna Wrote numerous letters

April 14 Worked on recorder detail drawings. Dfed out a decrements for measuring decrement of received signal. Used B arm edge & I enlarged on it & I- converter in closing a contact with the tuning condenser at resonance & off resonance different amounts & getting ratios of audibility with equal signals at both contacts

April 15 Worked on recorder drawings (. Got short wave receiver & ready for tests with Conrad. Wrote (monthly report.

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April 17 to 22. F W Dunmore

April 17 to 19. Went to Chicago to present paper on relay recorder before the convention of the AIEE

Apl 20 On annual leave (1920) 16 Sunday
Apl 21 "
Apl 22 Answered letters. Showed visitors around ~~Stockade~~ radio lab. Repaired 100 watt loop transmitter. Set recorder up again Talked over beacon rotations

April 24 to 29. '22. F.W. Dunmore

April. 24. Wrote up report on WCT. 2 measurements. Took 4 Hours leave

April 25. Re-wired 1000 volt generator to give 2,500 volt wire dynamo in parallel Put in 3 more type 6 tubes & worked with them trying to get the 3 to work in tandem.

April 26. Worked on short wave set trying to make tubes work in tandem. Have trouble with the tubes, the plate current get excessive. By putting about 100 ohms shunted by an .002 condenser in the plate circuit I got much stabiler operations.

April 27. Went over Recorder working drawings & made additions. Half holiday.

April 28. Developed a regenerative 100-150 meter receiver - detector & 2 stages of audio amplification for tests short wave tests with Pittsburgh.

April 29. Got short wave tests set ready for this evening tests. Put short wave receiver down on shack & got it working OK on 135 m. Made tests with 8XK (Conrad, Pitts) at 10 15. We got one tube on 1 tube. Used 2 amps in 40 ft. aerodyn condenser coil aerial. Single (3 wire parallel) turn loop. 115 metres. Got him too, on 135 metres

may 1 to 6 '22 F. W. D. [illegible]

may 1. Worked on Recorder drawings. Wrote letters. Read over an Crosley confidential report. Cleaned up room 208.

may 2. Worked on recorder drawings. Read sketch made of 100 meter loop. Put up a 135 meter receiving loop & tried to get set to oscillate on same no knocks yet. Took 3 hours lay

may 3 Worked on 135 meter receiving loop. Tested out cloth loop on S.C receiver Tested out recorder 110 volt transformer which B ain has completed.

may 4. Got Signal Corps started on making 2 type B recorders got pictures together for recorder article in R news. Worked some more on 135 meter receiver

may 5. Got 115 meter loop receiver working. Got new calibration on decremeter & checked wave & found it to be 100 meters. Took H.V. generator down in shack.

may 6. Got material together for 2 recorders for Signal Corps. Got ~~set~~ 100 meter set in shape for tests tonight. Came back in evening & worked 8XK Conrad, in Pitts OK. ~~Sent~~ Sent on 108 meters & received him on 135 meters Heard a station in B also too. Got Conrads phone. Did receiving on a 20 ft square loop. Got 5 amps in transmitting loop & he got no fire.

may 8 to may 13 22, F W D wrnmore

may 8. Attended conference on Beacons. Took 1½ hours leave. Set up list of Cos interested in DF mfg & got telegram doped up to send to am to come to conference

may 9. Wrote up digest on DF situation, made a 100-15 a meter vario condenser. Took dimensions of new recorder Paine is making. Wrote letter to Conrad re- schedule of short wave tests

may 10 Attended group chief meeting. Collected all DF dope for conferences. Made another set of spreader condensers to put in S. side of ac set up Book

may 11 Started making up an amplifier with one stage of RF amplification Attended meeting of D vector. SEE PAGE 10. Made out list of oil panels in Beacons

may 12 Got material together for DF meeting at Commerce Bldgs Attended meeting Showed Conrad Engineer around Lab. Made 3 inch rod insulator for new spreader condenser

may 13 Set up new short wave receiver down in attacks for short wave tests.

May 15 to May 20. F. W. Dunmore

May 15. ~~Cleared up incomming tray~~ On annual leave

" 16 " "

" 17 "

" 18 Cleared up incomming tray. Ran a test with 8 XK sending every half hour from 12 noon to 9. P.M. Worked the test until six P.M then Dunmore took it till 9. Worked him OK in daytime.

" 19 Worked all day putting a spreader condenser in the side of the 100 metre coil aerial.

" 20 Finished condenser & worked on tuner set re-turning It tuned to 100 metres in place of 105, got 4, 8 amps.

" "

F W D Wunmore May 22-27 '22.

May 22. Checked over drawings on spreader condenser coil aerial. Worked on two of the magnet coils for the 2 Sig Corps relay recorders. Took 1½ hrs lean

May 23 Wrote letter to Dayton re short wave tests. Started report on the 105 meter short wave transmitter

May 24: Wound relay magnet coils. Revised drawings of recorder & got Diaz started on them. Worked on 105 meter transmitter report.

May 25 Set up receiver Directr. had; no permanent set-up in 203, Worked on 2 type B recorders for signal corps

May 26 Worked wiring up the 2 type B recorders for signal corps

May 27. Continued work on recorders.

F. W. D. memorandum. May 29 to June 3 '22

10

May 29 Worked all day rewiring up 2 type "B" recorders for signal corps

May 30 Holiday.

May 31 Finished one recorder & tested it out & got it working OK
Found one had wrong & a broken down paper condenser.

June 1 Worked on second Type "B" recorder for signal corps.

June 2 Finished wiring & tested out & delivered out to Signal corps. Carried out short wave test with E & A sending on short wave loop (105 metres) See Purnell rds no 911-A. Send first with spreader condenser in top section of coil, then shorted it & put one in South side of coil & send again.

June 3 Wrote letters Read over dope on 14 metre short wave tests carried out in England. Worked on mush-up of 105 metre coil and transmitter.

PLAINTIFF'S EXHIBIT No. 24—Continued

F. W. Dunmore June 5 to 10

June 5. Worked on 100 watt transmitter write up. Ran short wave test with 8 X K from 12 noon to 9-30 PM.

June 6. Proof read Scuello RF ~~amplifier~~ & AC amplifier paper. Got material together to have good 100 watter receiver made up.

June 7. Went over completed Record drawings. made several corrections & additions. Wrote Bitters re short wave tests. measured Relay transformer voltages for data to go on relay drawings.

June 8. Worked most all day on design & lay-out of a short wave receiving set. Wrote over a letter to Conrad re-short wave tests.

June 9. read exploring receiver with permit tube & made tests around short wave coil aerial to determine directional properties. Worked on short wave receiver design. Talked with Tupper re- Yagis antenna design for Lightship beacons

June 10 Worked on short wave receiver. Wrote up last short wave test in report. got copy at /.

7 WD Journal June 12 - 17. 22.

June 12 Worked with relay for Signal Corps & got some tape on 7th Wood. many data & 2 stop sending. Finished design on short wave receiver

June 13. Got together material for putting a spreader condenser in the N down lead on short wave coil aerial Went over short wave receiver drawing with F.C. Went down town & got equipment for short wave receiver

June 14. Checked over recorder drawing. Got chap & carpenter started on short wave receiver. Demonstrated recorder according to Col Molesworth.

June 15 Consulted with Clark & Prues of Radio Corps & Wireless Spec Off. Co re DF design. Wrote monthly report. Went down town to Sig Corps office & got relay (Exhibit B) to working.

June 16 Put new spreader condenser in N down lead of 100 meter aerial coil Rotary set with same. Worked on short wave receiving set.

June 17 Put new rope in 105 meter antenna. ~~Worked~~ Put field wire in motor & got 1 amp more in antenna

F W Dunmore June 19 - 24 '22.

June 19. Worked on short wave receiving set. Carried out test with 8XK to see if coil aerial is directional. Sent with condenser in centre of top. & then with it in centre of S down lead

June 20. Attended meeting on construction of simple detector & amplifier. -all morning Worked on short wave receiving set.

June 21. Worked on short wave receiver all day.

June 22, Wrote letters. Tried 100 metre set with condenser down in centre of the lower part of coils. Worked on short wave set

June 23, Worked all day on short wave receiver. & completed same.

June 24, made directional tests with short wave transmitter. Put aerial condenser in top, 2 coils, & bottom & made tests. Eagle Station answered in.

June 26 to July 1 22. E. W. Dunmore

June 26. Worked up data on short wave tests both from our field tests & S A E. made over short wave receiver to adapt it for use with a soft detector tube

June 27. Went out in Park & tested short wave receiver. Found moorhead hard tubes to work most smoothly. Reductions 201A & a 200 detector ~~was~~ was the most sensative combination attended meeting

June 28. Worked on short wave receiver trying to get it to oscillate properly. Found moorhead tubes to be more satisfactory ~~than~~ Wrote letters Conrad

June 29. Took 3 Hours leave. Worked on a modulator for the 100 meter tube transmitter. Tried various methods of ~~grid~~ modulation

June 30. Continued modulation tests. Hooked up plate power absorption method of modulation & started testing with it. Took ½ hr leave

July 1. Proof read ULP's MSS ~~with~~ ~~[illegible]~~ of a tube detector receiver. Got 100 meter phone set working very nicely & set ~~[illegible]~~ the operativity of modulation was not perfect,

July 3 to ~~July~~ 8 22. F.W.D worrorr

July 3. On leave

July 4 Holiday

July 5. Prof. read M S S & J L P's write-up on a regenerative receiver. Worked on 100 meter radio phone ~~made complete test & found that due to loose tube tests were not received~~

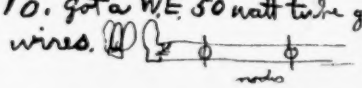
July 6. made complete 10.5 meter directional transmission & phone tests & find tests were N G as truck went on the burn & after ate could not receive com

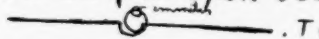
July 7. Had to drop field tests on account truck. Started work on a 10 to 20 meter Transmitter

July 8 Set up two complete sets of ~~new~~ transmitters with Eagle Sig. oscillator & ran 10 to 20 meters after words the set would not work

Holiday

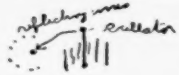
July 10 to 15, 22. F. W. Dunmore.

July 10. Got a W.E. 50 watt tube going at 12.4 meters. Measured the λ with 2 parallel wires. 

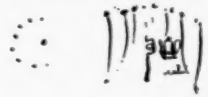
July 11. Made up an open oscillator antenna & coupled same to tube generator. T has 

. T used it by cutting off the ends inch by inch with scissors

July 12 Made further tests with above oscillator trying to modulate same. Looked up refs on light reflection. Had a talk with the Director

July 13. Worked out design of a reflector for 12 meters 

July 14. Finished getting rope & pully up to tower 12 meters up, reflector. Ran plate & fil supply lead out to grate tube. Wrote up monthly report. Read DF Speco. & made few corrections & additions.

July 15. Worked on 12.4 meter reflecting system. 

Half holiday.

July 17 to 21. '22 F. W. Dunmore

July 17. Put up an antenna for Beak for the time recorder. Also put in a ground & ground switch. Completed spec. on Recorder

July 18. Talked over patent difficulties with ECC & Speight. Studied parabolic reflectors for short wave radio reflection. Decided the principl focus should be $\frac{1}{2}\lambda$.

July 19. Had a talk with E.C.C. Had further conference re. patents with Speight. Started report on portafone. Got short wave set down to 9 meters.

July 20. Tried to get tube oscillating at 6 meters but found that the W.E. type G tube we were using had a coiled lead-in which made it impossible get below 8 meters. Wrote a report on the "Portafone"

July 21. Cleaned out compass house of material not in use. Heavy stuff etc. Got list of all tubes possibly charged to me & had J.A.P. make a list to check it against. Tried to get a French power tube & a U.V. tube to going on short wave but couldn't get em to oscillate

July 22. Bent glass rods for insulators on 6 meter reflector. Talked with Capt Andrews re- D.F. He is laboring up D.F.'s in Sig. Corps

July 24 to July 29. F. W. Dunmore. 1922

July 24. Wrote letter re special type of W.E. type G tube for 6 meter work. Worked out possible plan to string up a reflector for 12 meters but decided it would be impractical. Started work on 2, 12 meter oscillators to be operated together at same λ.

July 25. Went over Riecron drawings with J.L.P. & told Buckley what changes to make

July 26. Measured λ of 2 parallel operating tube sets & found it 10 meters Started wave meter calibration for short waves. Worked out parabola with Engle for a 10 meter λ Learned that focal dist. should be $\frac{1}{4}\lambda$

July 27. Went to Baltimore & turned up diamond shoal Lightvessel beacon Had to return both sets. Each to 1000 & 600. Got 9 amps on 1000 & 10 on 600.

July 28. Made out expense acct. Tested out Time relay & delivered it to Neal made many changes on report re portafone. Worked up dope on 10 meter transm. altar. Going to have 17 turned wires in parabola with 33 ft aperature. Radiator 2 ½ wall 10 meter tube sets going into same antenna. Antenna 5 wire cage type

July 31 to Aug 5, '22.

July 31, 3 mounted 40 meter oscillator tubes platform 3 sets P. 9 note book). Made up a central load for operating tubes from the ground. Soldered the 5 wire lead control wires.

Aug 1. Worked up note books. Put new power line down to shack. Got 100 meter transmitter & receiver in shape for tests with Conrad tomorrow. Carpenter finished parabolic reflector frame from which tuned wires will hang.

Aug 2 Went to 8XK on 100 meters. & listened for him on same λ

Aug 3 to 5 on annual leave.

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PLAINTIFF'S EXHIBIT NO. 25

WEEKLY REPORT CARDS OF P. D. LOWELL

August 1-6, 1921 P. D. Lowell

Continued work on Signal Corps radio trailer compass.

Continued tests with various circuits for balancing out static in audio frequency

PLAINTIFF'S EXHIBIT No. 25—Continued

August 8-13, 1924 P. D. Lowell

Continued work with Bohm on trailer radio compass for Liquid Corp.

Made more tests with static elimination circuits.

Remade over 1605-B amplifiers for 600 to 1000 meters using iron core radio transformers.

Aug. 15 – 20, 1921 P. D. Lowell

Worked with Bohner on tests in field with trailer radio compass.

Aug 22 – 27, 1921 P. D. Lowell

On leave

1921 Aug 29 - Sept 3

On leave.

Sept 5—10, 1921 C. D. Lourie

Worked with Bohnee on tests with trailer radio compass. Making new type of rotating switch for connecting the two loops alternately into the circuit

Sept 12–17, 1921 P. D. Lowell.

Worked with Bohnen on trans. radio compass problem. Preparing for tests with plane at Bolling Field.

Made some preliminary tests with transmitter on plane to familiarize ourselves with its general operation, working range etc.

1921 Sept 19—24 P. D. Lourlb

Continued work at Bolling Field with ~~Bolmer~~ Bolmer on trailn compass set.

Made several flying tests with 13 spark set on plane and about 250 ft. antenna on 550 meters. Tests indicate great errors and other difficulties due to the varying directional characteristics of the trailing wire antenna.

January 3 – 7, 1922 — P. D. Lourie

3 Repaired portable time signal set, putting in new design radio transformer and adding a number of turns to loop to bring it up to Arlington's new wave length of 2600 meters.

4 Worked on high frequency bridge, using a buzzer as source of signals instead of type P pellotron as has hitherto been used.

5 Worked on high frequency bridge. Coupled buzzer into input and connected coil + condenser to output and then to det. + 2 audio stages. Get perfect balancing.

6 More h. f. bridge work

7 "

Jan. 9 — 14, 1922 P. D. Lowell

9 Worked on H. F. bridge to determine effect on balance at various frequencies with coil of unknown value in one arm and resistance in other arm. With resistance in, balance was destroyed when source of input e.m.f was tuned to frequency of unknown coil across condenser.

10 Set up amplifier circuit, 1 R.F. tube detector + 1 A.F. to work on filaments on 60 v supply. Found that hum could be reduced materially by connecting grid circuits to voltage dividers across filament supply voltage. Used batteries for plate voltage.

11 Tried 2 R.F. stages + crystal det. Worked much better with crystal detector than with tube det. Various circuits tried to reduce hum when using tube det. little success, however.

12 Wrote outline for Dr. Dellenger. Tried more circuits with tube det. on A.C. 60 v but with no further improvement.

13 Tried 3 R.F. stages, crystal det. — A.C. on filaments and rectified A.C. on plates. Used Moorehead tube to rectify 80 volts A.C. for plates. This source of plate voltage seems fairly satisfactory but quite a hum due to A.C. on filaments

14 Wrote reports (notebook — monthly + weekly) On leave in P.M.

January 16 - 21, 1922 P. D. Lowell

Jan. 16 - Conferred with Mr. Cox on H.F. bridge problem. He is to have the condensers calebrated so that actual H.F. measurements can be attempted. More work on amplifier using 60 ~ A.C. on filaments + plates, Mr. Dunmore co-operated. Found that when 60 ~ hum is balanced in grid circuit that there is a small 120 ~ hum left due to change in plate current when fil. temp. changes. Cannot balance it out.

Jan 17 - Found R.F. amplification increased and hum decreased by introducing ca. .02 mfd. cond. in series with R.F. grids. This must allow the grids to assume a more favorable voltage for amplifying. Tried 1 R.F. stage, crystal det. + 1 A.F. stage; a .02 mfd cond. shunted by 80,000 ohms, in A.F. plate helped cut down hum.

Jan 18 - Tried more tests to use tube detector but with poor results. Set up Tungar rectifier for filament current supply.

Jan 19 Rectified A.C. on fils. is N.G. due to unsymmetrical form of D.C., cannot smooth it out sufficiently and cannot balance out hum in grid circuit.

Jan 20 Back to pure A.C. on fils., works better. Set up 2 R.F. stages, crystal det. and 2 A.F. stages. Quite "hummy" but much improved with .02 condensers in grids and plates. Rectified A.C. used on plates.

Jan 21 Assisted Mr. Dunmore on some experiments with his recorder. Ox leave at 3:00 o'clock

January 23 — 28, 1922 P. D. Lowell

Jan 23 — F. W. D. + D. set up Magnavox to work on 110 V-60 ~ A.C. in conjunction with A.C. operated amplifier.

Jan 24 — Got Magnavox working on 60 ~ A.C. using Jungar for rectifying A.C. for field coil. Connected it to A.C. operated R.F – A.F. amplifier and got very good results throughout. Only slight hum present. Helped Dunmore on recorder tests.

Jan 25 — Tried "C" battery in grids of amplifiers and found improvement in elimination of hum as well as in amplification and stability of operation.

Jan 26 — Made some practical tests with A.C. operated amplifier and Magnavox. Speech from several stations reproduced very nicely. Recommend two sets be made up in shop – 1 RF – AF amplifier and 1 Magnavox set for laboratory use.

Jan 27 — Tried tube detector again but got no encouraging results.

Jan 28 — Helped Dunmore on some recorder tests. Conferred with a visitor on some receiving circuits for his information.

Jan. 30 — Feb 4, 1922 P. D. Lowell.

Jan 30 — Started design of 5 tube A.C. amplifier.

Jan 31 — Started shop drawings for " "

Feb 1 — Worked on " " " " "

Feb 2 — Mr. Buckley took over drawing and design of A.C. amplifier. Conferred with him on same.

Feb 3 — Conf. Mr. Buckley re. A.C. amplifier design
Made some practical tests with A.C. amplifier.
Conf. Dr. Brooks re. transformer design.

Feb. 4 — Worked with Mr. Buckley on amplifier design details
Worked on job of proper rectified A.C. supply for Magnavox field coil.

Feb. 6 — 11, 1922 P. D. Lowell.

Feb 6 — Conf. Buckley re. drawings for A.C. amplifier.
Asst'd Mr. Dunmore on some recorder tests.

Feb 7 — L.E.W. J.W.D. J.A.W. and self in conf. rec. short wave transmission and reception problem for Signal Corps. Exper. with transformer windings for Jungar rect. tube filament. Attended Mr. Whittemore's talk on Radio Broadcasting.

Feb 8 — Trying to get best A.C. voltage on Jungar plate to give proper D.C. voltage on Magnavox field coil. Talked with Sanford, magnetic section on proper design for power transformer.

Feb 9 — Made up A.C. power transformer with 5 windings for use with A.C. amplifier and Magnavox.

Feb 10 — Started design for complete rectifier unit to go with A.C. amplifier. Section meeting in P.M.

Feb. 11 — Tried some speech amplification using 2 audio freq. stages and Magnavox, all on A.C. Some distortion due to sharply tuned A.F. transformers. Modulation transformers worked better. Amplification is very good with very little A.C. hum.

February 13 – 18 – 1922 P. D. Lowell

13th – Wrote report on A.C. operated amplifier for publication.
Tried resistance coupled audio freq. stages in A.C. amplifier, better for speech amplification but not so much amplf. per stage as transformers.

14th – Worked on shop drawings for rectifier unit for A.C. amplifier.

15th – On leave.

16th – Conf. R.S.O. re. publication of A.C. amplifier report.
Re-wound filament transformer windings for A.C. power transformer.
Investigated catalogs + ordered some apparatus.

17th – Worked on shop drawings for rectifier unit.
Amateur Radio Convention.

18th – Tried modulation transformers in A.F. stages of A.C. amplifier. better for radiophone speech + music but not as much amplification per stage as audio freq. transformers.
Tried choke coils in series with plate voltage supply to smooth out rectified plate current. Helped somewhat to reduce hum.

Feb. 20 – 25, 1922 P. D. Lowell.

Feb. 20 – Started construction of A.C. amplifier in shop. Got all parts together. Cut + drilled bakelite panel. About 5 hrs in shop

Feb. 21 – In shop on amplifier about 6 hours. Fitting bakelite shelf.

Feb-22- Holiday

Feb-23 – In shop on amplifier about 6 hours. Making battery cases and other small parts.

Feb. 24 – In shop on amplifier about 6 hours. Mounting transformers and other pieces.

Feb. 25 – In shop on amplifier about 4 hours, assembling + fitting parts. Made up a new telephone transformer.

Feb. 27 – Mar. 4 – 1922 ..... P. D. Lowell

Worked entire week on finishing machine work, assembling J parts, wiring and testing A.C. amplifier unit. Having some trouble in making it work properly. Rectifier unit is still unmade.

March 6 - 11, 1922 P. D. Lourell.

Mar 6 — Worked on A.C. amplifier trying to make it function properly.

Mar. 7 — Found plate voltage rectifier not operating properly and fixed it. Put additional choke coils in rectifier circuit.

Mar. 8 — Worked more on AC. amplifier. Found method of limiting DC. voltage output regardless of rectifier filament.

Mar. 9 — Continued tests to improve operation of A C. amplifier.

Mar 10 — Ditto. Also took some turns off filament windings of power transformer.

Mar 11 — Continued tests on AC. amplifier. Started report on R.F. amplification.

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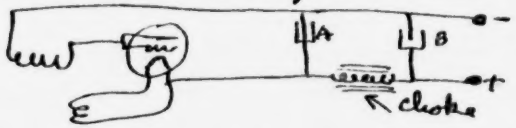
March 13 – 18, 1922 P. D. Lowell

Mar 13 · Wrote on Radio Frequency Amplifier report.

Mar. 14 – Made some changes in A. C. amplifier. Put a 1 mfd. cond. from det. to filament, helped to reduce hum. Found that a choke in rectifier circuit helped some. Thus:-



With this choke in it was found that the smoothing out condensers could be reduced to 2 mfd. each.

Mar. 15 – Further tests with A.C. amplifier. On leave in P. M.

Mar. 16 – " " " " " trying to improve operation

Mar. 17 – " " " " " " " "

Confer. with a Mr. Haling on receiving circuits

Mar. 18 – Making plans for assembly of rectifier unit for A.C. amplifier.

PLAINTIFF'S EXHIBIT No. 25—Continued

March 20 — 25 1922 P. D. Lowell

Mar 20 — More tests with A.C. amplifier. Ground connection on filaments helps reduce hum.

" 21 — Trying to make over a telephone receiver to serve as a good loud speaking reproducer.

" 22 — Ditto. Spacing diaphram farther from poles and ear cap farther from diaphram allowed good reproduction without distortion. Used with large horn.

" 23 — Rewound receiver coils with 400 turns and used with step-down transformer to supply current. Worked about same as with high value winding.

" 24 — Tried increasing magnetism of pole magnets by winding a magnetising coil on it, current from battery. Increasing magnetisation no better. Diaphram probably saturated.

" 25 — Heavier diaphram not better.

Tried 2 tubes to rectify plate voltage, using both sides of A.C. cycle. Some what better results but not much.

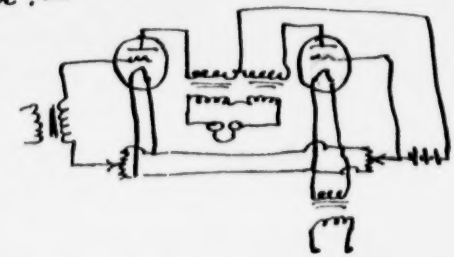
March 27 — April 1 — 1922 P. D. Lowell

Mar. 27 —— Worked on drawings for rectifier unit to go with A.C. amplifier.

Mar. 28 —— Made temporary mounting for rectifier unit to take home for test.

Mar 29 —— Worked on drawings for rectifier unit. Helped Dunmore on receiving end of 100 meter transmitter.

Mar. 30 —— Made tests with detector tube, filament on A.C. Single detector is good but when audio is added, hum is too great. Demonstrated possibility of balancing out hum with double tube circuit:—



Mar. 31 —— Helped Dunmore on R.F. amplification circuit for 100 meters.

April 1 —— Worked on drawings for rectifier unit.

April 3-8, 1922 P. D. Lowell

April 3 — Finished drawings for rectifier unit. Started construction of rectifier unit in shop.
April 4 — Worked on rectifier unit in shop.
April 5 — " " " " " "
April 6 — " " " " " " Rewriting report on radio frequency amplifiers.
April 7 — Worked on R.F. amplifier report. In shop on rectifier construction
April 8 — Worked on R.F. amplifier report. Finished rectifier. Started carpenter on making wood cases for A.C. amplifier and rectifier.

April 10 – 15, 1922 P. D. Lowell

10 — Work on R.F. amplifier report. Work on rectifier unit.

11 — On R.F. amplifier report. Designed case for A.C. amplifier.

12 — Further tests with A.C. amplifier using a negative "C" battery in R.F. grids. Gives little better results. More stable operation seemed with about 80 – 100 volts on plates.

13 — Tests with A.C. amplifier. Revision of R.F. amplifier report. On leave in P. M.

14 — Revision of R.F. amplifier report. Showed visitors around Lab. Helped carpenter on case for A.C. amplifier.

15. — Conf. textile section re. possibility of weaving a wire in a cloth tape for making flexible loops. On leave in P. M.

April 17 — 22, 1922 P. D. Lowell

17 — Fixed up long wave receiver. General lab. work Showed visitors around.

18 — Fitted A.C. amplifier to its case. Designed horn to fit into case lid. Started carpenter making horn.

19 — Designed folding loop to fit in amplifier case. Showed visitors around. General lab. work.

20 — On leave in A.M. Fixed up loud speaker + horn in conn to AC. amplifier.

21 — Conf. visitors on R.F. transformer design. Showed visitors around lab. General lab. work.

22 — Rubbed down + polished A.C. amplifier case. Worked on R.F. amplifier report.

April 24 — 29, 1922 P. D. Lowell.

24— More work on A.C. amplifier. Trying to reduce R.F. oscillating when 3 R.F. stages are used.

26— Worked on A.C. amplifier. Entertained visitors. General lab. work. On leave in P.M.

26 — Entertained a Mr. Frauzblau re A.C. amplifier. Hiked up amplifier for test at home.

27 — Very good results with amplifier at home. Conf. Mr. Doig re drawings for R.F. amplifier report. Entertained visitors.

28 — Entertained visitors and others interested in A.C. amplifier. Worked on R.F. transformers for A.C. amplifier.

29 — Worked on A.C. amplifier trying to stop R.F. oscillating. Entertained visitors and a Mr. Eaton re A.C. amplifier.

PLAINTIFF'S EXHIBIT No. 25—Continued

May 1 — 6, 1922 P. D. Lowell

May 1 — Worked on RF. stages of A.C. amplifier. Trouble caused by RF. oscillations producing loud hum when 3 R.F. stages used.

2 — On A.C. amplifier. Best operation obtained with only two R.F. stages. On leave in P.M.

3 — Finished construction of flexible loop for use with A.C. amplifier. Made up experimental amplifier setups for making tests at 100 meters.

4 — Started experiments on 100 meter amplification

5 — Entertained visitors. Worked on RF amplifier for 100 meters. Think that air core RF transformers will be best.

6 — Worked on 100 meter amplifier. Made some spirally wound "spider web" coils for RF transformers for 100 meters.

May 8 — 13, 1922 P. D. Lowell

8 —— Worked on R.F. amplifier for 100 meters for S. W. D. Tried air core transformer with "spiderweb" coils. Range too narrow.

9 —— Tried iron core R.F. transformer wound different turns and forms but at best was to restricted in range.

10 —— Made up a tuned plate amplifier stage using a ½" square bakelite tube wound with 100 turns, fitted with sliding core for tuning. This gave good operation from 80 to 200 meters with controllable oscillations at any point.

11 —— Making up a small variometer to try for tuned plate coupling in place of tuned iron core choke. Helped Shea fix up buzzer line to compass house.

12 —— Worked on small variometer. Entertained visitors. Helped S. W. D. make tuned plate amplifier for tests with Pittsburgh.

13 —— General lab. work, straightening up lab. Entertained visitors. Worked some more on R.F. 100 meter amplification.

PLAINTIFF'S EXHIBIT No. 25—Continued

May 15 — 20, 1922 P. D. Lowell.

15- More work on 100 meter amplifying circuits using resistance coupling. Could not make circuit oscillate below 200 metres.
16- Tried new type of single layer coil for tuned plate coupling but could get only restricted range.
17- Talked with a Mr. Paul on construction of receiving apparatus. Helped Mr. Bohner in repairing amplifier.
18- Started writing 6 abstracts. 3 on A.C. amplifier and 3 on R.F. amplifier circuits. Repaired amplifier which was used on Tulip.
19- Fixed up long wave receiver (permanent set-up). Helped Mr. Bohner on some amplifier circuits. Entertained visitors.
20- Entertained man from G.E. Co. re. A.C. amplifier circuits. Straightened up lab. On leave in P.M.

May 22 — 27, 1922 P. D. Lowell

May 22 — Entertained 2 parties of visitors. Assisted Mr Preston on making list of Manufacturers of radio apparatus On leave 2:00 P. M.

23 — Writing abstracts of A.C. amplifier paper. Fixed up A.C. amplifier for taking its picture.

24 — Writing abstracts for A.C. amplifier paper.

25 — Writing & rehashing abstracts on A.C. amplifier paper also radio-frequency amplifier paper.

26 — Ditto

27 — Ditto

May 29 — June 3, 1922 P. D. Lourell.

May 29 — Worked on details of new 100 meter amplifier which will have 1 stage tuned plate R.F. amplification, detector and two audio stages. Plate tuning accomplished by means of sliding iron core in and out of a ½" square coil of # 38 wire.

30 — Holiday

31 — Designing details of plate tuning arrangement.

June 1 — Locating & fixing trouble in long wave French receiving set, (permanent setup). Worked on arrangement of parts for 100 meter amplifier.

2 — Working out details of 100 meter amplifier.

3 — " " " " " Made up some rough sketches for same.

June 5 — 10, 1922 P. D. Lourell

June (5) — Moving some of my stuff to Preston's section for work on audio amplifier for publication. Started construction of rough 2-steps amplifier. Collected parts

(6) — Sawed out bases + panels for 2 sets. Assembled and fastned down parts to base + panel.

(7) — Wired up and tested one set. Worked O.K.

(8) — " " " " other " " " Tested the two stages in cascade. O.K. averaged about 10 times per stage or 100 for 2 stages of amplification using General Radio Co. transformers.

(9) — Further tests on amplifier. Worked with Ould on changeing R.F. amplifier Scientific Paper.

(10) — Started writing material to go with audio amplifier. Drew design for finished amplifier.

June 12 – 16, 1922 — P. D. Lowell.

12 — Further work on design of 2 - 1 stage audio amplifiers for letter - circular.

13 — Started making up finished sets (2 - 1 stage audio amplifiers).

14 — Worked on audio amplifiers. Assembling panels & bases.

15 — " " " . Assembling transformers, sockets, rheostats and binding posts. Mounting parts.

16 — Started wiring sets.

17 — Finished wiring. Ready for testing and writing instructions for making.

June 19 – 24, 1922 P. D. Lowell

19 — On new job. To design and make Arlington time signal receiver and recorder for ~~time~~ clock section of Bureau. This set to replace leased wire service if possible.

20 — Set up experimental outfit consisting single circuit tuner, (coil + var. cond. in parallel), detector tube and two audio stages. 20 volts negative on second audio grid and relay in plate of 2nd tube. Relay rewound to about 1000 ohms.

21 — Found that set worked ok without 20 volt negative grid battery because of strength of signals. Started design of set to be made in shop.

22 — Worked on shop drawings for time recorder set.

23 — " " " " " " "

24 — " " " " " " " Finished same and submitted to Preston for OK. and to get started in shop.

PLAINTIFF'S EXHIBIT No. 25—Continued

June 26 — July 1, 1922

C. D. Lovell.

26— On leave in A. M. Straightening up fittings tables lift by me in room 203. Moved unit of stuff from my desk in 203

27— Got mechanic started on time recorder unit.

28— More work on audio amplifier for Runtz. Re-wired one set with new socket and shielded and transformers.

29 — Completed wiring of amplifier sets.

30 — Spent day loading apparatus shipped to me.

1 — Helped Mechanic on time recorder unit. Half day M.

July 3 — 8, 1922 ..... C. D. Lourell.

3 —
4 — } Making arrangements for leaving Bureau. Checking up
5 — apparatus charged to me. Assisted mechanic in
6 — construction of time signal relay
7 —
8 — } Changed wiring on one of audio frequency amplifier sets for Preston.

July 10 — 15, 1922 — P. D. Lowell.

Made all final arrangements for leaving Bureau, fixing up clearance sheet, etc. Conf. with Director regarding my leaving.

Got tuner signal relay from shop, wired it up and tested it out with good results. Cabinet for set not yet made but made drawings for same. Installation of set and antenna will probably be done by Strock.

PLAINTIFF'S EXHIBIT NO. 26

DUNMORE LABORATORY NOTEBOOK

3

Amplifier Design.

Constants of navy Amplifier
Radio Audio Freq.
Amplifier. 6 step
4 aa radio, 1 audio 1 detector

GE Co. 1605 A or B remodeled

Circuit Diagram

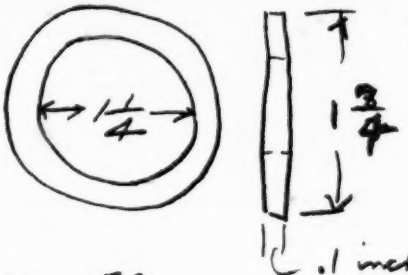
See Blueprint
BS Radio no — 517

over

PLAINTIFF'S EXHIBIT No. 26—Continued

4

Radio Frequency Transformer.



Primary, D.C. Res = 56 ω
Secondary " " = 59 ω

Size wire - no 36 enamel
single Silk covered.

(natural period of [illegible] Sec,
850 meters - Tube capacity
across coil.
Capacity of coil approx 5 micro-micro-farads measured @ H.F
& inductance of " 7.5 millihenries.

There are 4 such radio freq.
transformers, and 1 audio freq
transformer.

PLAINTIFF'S EXHIBIT No. 26—Continued

Amplifier Design 7
12-19-19

300 T		400 T	
No coils	λ	No coils	λ
1	800	1	600
2	460	2	875
3	575	3	1100
4	675		

375 T			360 T
1			
2		2	
3	950	3	875

325 T		350 T	
1			
2			
3	850		

6 coils 350 turns each
3/32" thick 5/8" i.d. 1 1/2" o.d.
#36 d.c.c

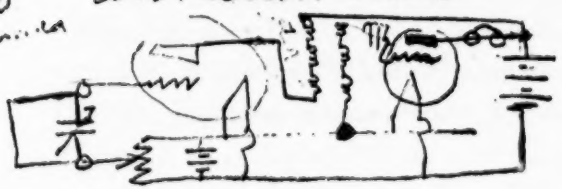
over

PLAINTIFF'S EXHIBIT No. 26—Continued

8

Three of these coils in series with a variable capacity across them tuned at 850 metres.
An amplifier made up with a transformer primary consisting of 3 of these coils in series & a rec of 3 in series gave loudest signals from 1000 metres to 1800 metres.
connection thus.

330 turns

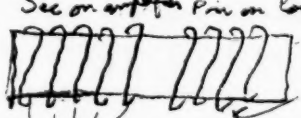


PLAINTIFF'S EXHIBIT No. 26—Continued

9

~~Jan~~ Dec 31

Tests with coupling from RC coil to amplifier.
Used 5" coil 13 turns spaced $\frac{1}{2}$"
Used small iron core transformer



Used .0065 mf condenser across Coup. B52461O-A.
1000 meters tuned at 72°
100 " " " 30°
Without coupling transformer
1000 meters tuned at 63°
600 " " " 25°

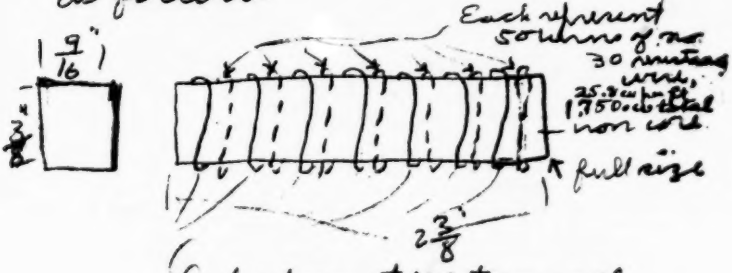
This connection ~~Feed tuned~~ tuned to 600 + 950 at same time

PLAINTIFF'S EXHIBIT No. 26—Continued

10'

Jan 2 1920

Continued tests of Dec 31. made several different types of coupling coils & found the best one to be as follows

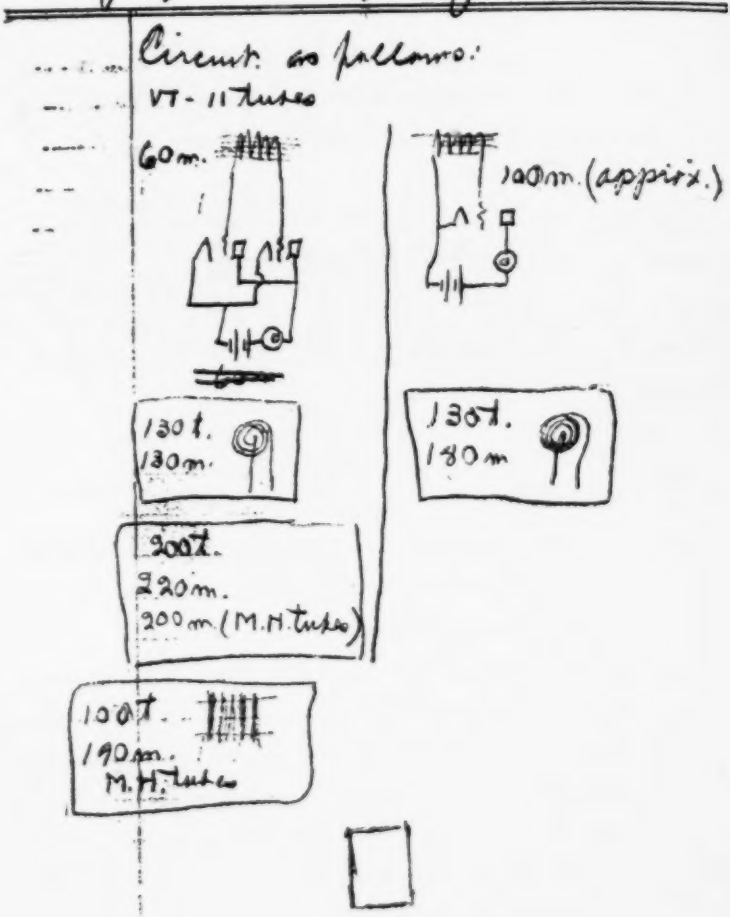


Each represent 100 turns of Litz no 36 SSC copper wire. This constituted primary & was connected to R.C. coil tuning condenser. Sec of resistance wire was connected to amplifier - navy 6 step 4 radio 1 audio 600-1000 m Used 5" loop 13 turns ½" spacing Such coupling made amplifier work very satisfactory & gave very good signals on 1000 m & good signals on 600 m.

See print Nos 517 for circuit of amplifier.

PLAINTIFF'S EXHIBIT No. 26—Continued

Amplifier Design Jan. 9, 1923



PLAINTIFF'S EXHIBIT No. 26—Continued

12

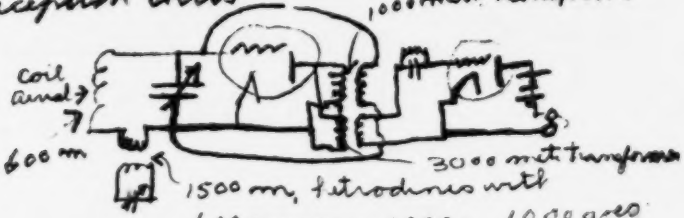
Jan 17 1920.

380 turns on an iron core of this size no 36 D.S.C. gives 1000 meter with movable tap

E.N.Scarrow

Jan 19 1920

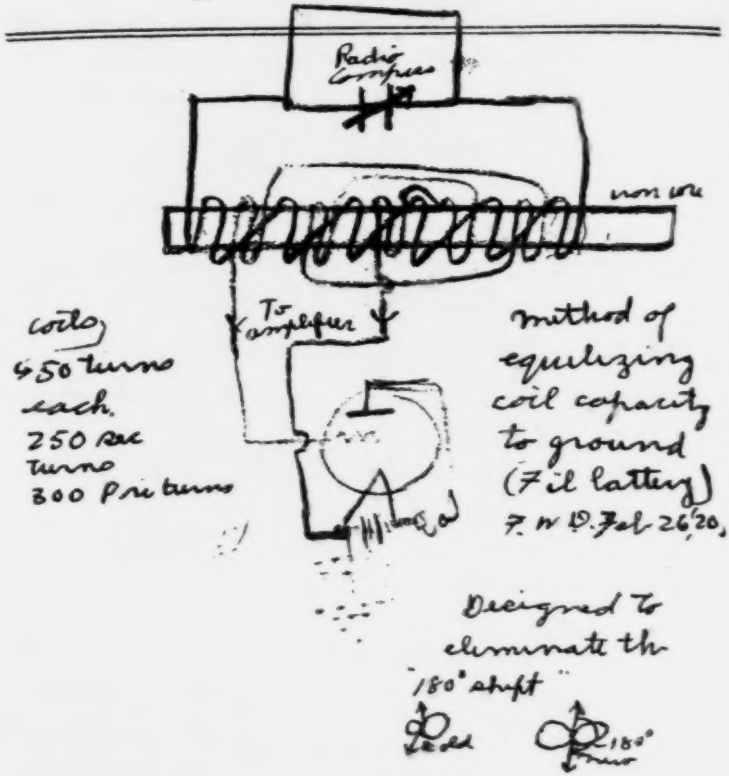
P.D. Sourland suggested tetrodyne reception thus



E.N.Scarrow

PLAINTIFF'S EXHIBIT No. 26—Continued

Feb 26 1920
method of coupling coil design 13

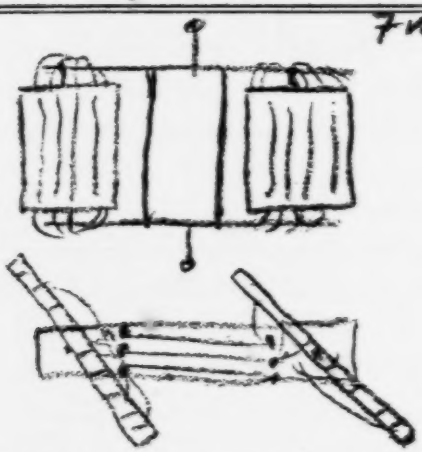


PLAINTIFF'S EXHIBIT No. 26—Continued

14

Feb 28 1920

F W Dunmore



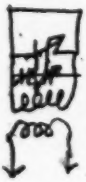
~~For~~ Radio Compass
to give sharp maximum

PLAINTIFF'S EXHIBIT No. 26—Continued

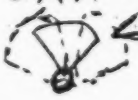
15

mch 4 '20.

In working with compass with
o on top of compass house noticed
the following!
By adjusting balancing condensers
a good min could be found but



if coil is revised 180° the
condensers must be adjusted
over again but just as good
a min. can be had & its
comes out to be in the same
direction. Therefore it makes
no diff from which direction
the rey comes with reference to
the pointer is the salient point is
adjusted for with a balancing
condenser the reading will be
OK. We will try mother light



room as made

PLAINTIFF'S EXHIBIT No. 26—Continued

16

mch 10.

Using circuit of P. 15. 4 sigs from Soldiers H at 1000 m. made some tests on min etc. Found a shift of 10° with 180° rotation even tho a re balance was made. It was noted that not when a fine balance was obtained at the min that it would vary fast we couldn't hear it then it came in Too many antennas there (8). When the telephone was touched at the min. was thrown away off.

mch 22, '20

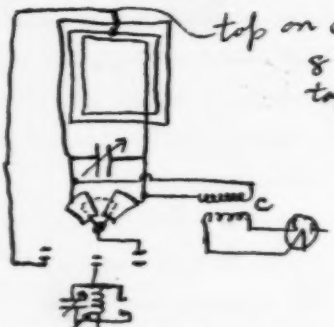
Tried out several circuits on signals on from Soldiers 1000 meters home. Found this circuit to work fine.

PLAINTIFF'S EXHIBIT No. 26—Continued

17

March 24 20

Found that unidirection circuit works best with no coupling that is like this.



Circuit to tune from 600 to 1000 m.
but not coupled into coupling coil C.

F W Dunmore

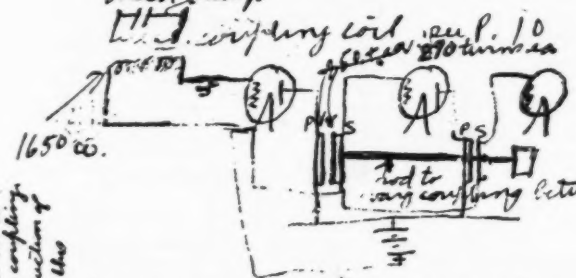
Compass on top of shack seems to have less sharp min & greater 180° diff than compass inside or on ground noticed that center taps or center of condenser method of uni direction works much better when coupling coil is used.

PLAINTIFF'S EXHIBIT No. 26—Continued

18

Mch 25 1920.

Best radio compass circuit todate. Same as on P. 17. but with amplifier made ~~thus~~ - with 3 radio stages of v-t-v coils as on page 4. Coupling between 1st. & sec. stage ~~as~~ is variable giving fine tuning from 600 to 1000 without stabilizer when coupling coil is used. Loop



Detector tube 1st with $\frac{1}{4}$" coupling max variable ~~to~~ to $\frac{1}{2}$" on other two, no stabalizer needed. Coupling very important. Seems to tune stages sharply & increases sensitivity 100 times

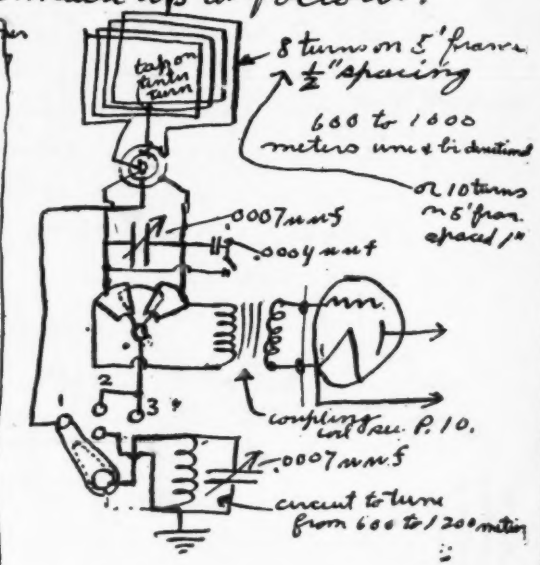
10 Sources used alternately for tuning & varying coupling. Loop and the coupling coil connected in series by telephone cord

PLAINTIFF'S EXHIBIT No. 26—Continued

19

Coto coils bought from coto people
2 sizes - 560 turns & 350 turns.
A compass receiving circuit
was made up as follows.

These are transparent coils are wound P & S in opposition with the outside turn end of HV end to grid on one coil & plate on other coil.



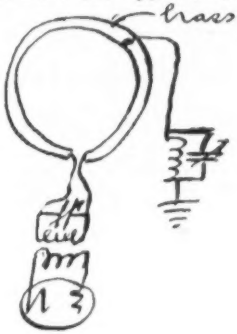
1 Unidirection using center tap
2 Bilateral reception
3 Unidirection using center of capacity

PLAINTIFF'S EXHIBIT No. 26—Continued

22

April 22 '20.

made tests with 10 turns in a ± 3/4" brass tube bent in a circle Static was very bad on compass on roof but less on pipe loops. Static - Signal ratio was better on brass pipe loop. Got good unidirection using the metal as antenna thus -

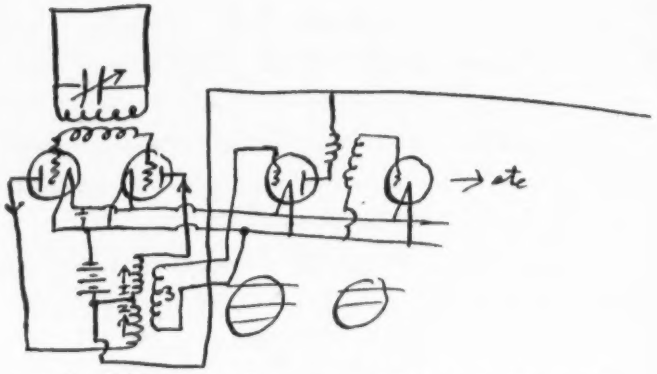


April 28 '20.

A circuit to give balanced capacity to earth ∴ no 180° shift in minimum

PLAINTIFF'S EXHIBIT No. 26—Continued

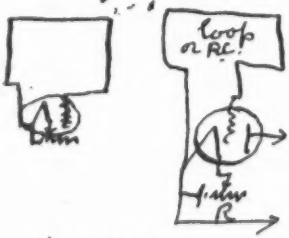
23



~~Get coils 1&2~~ Reverse coil 1 or 2 to get right polarity effect on 3. First radio frequency transformer has 2 primaries 1 & 2 rest are ordinary

---

Another shunt apl 2 & 2 d.



no tuning condenser
Use filament
shunt R to tune
with by changing
tube capacity
with fil temperature

"J" tube good.

PLAINTIFF'S EXHIBIT No. 26—Continued

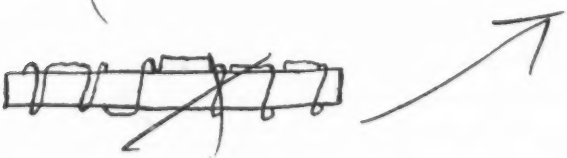
24

Apl 28 20

stunt to balance out capacity or antenna effect

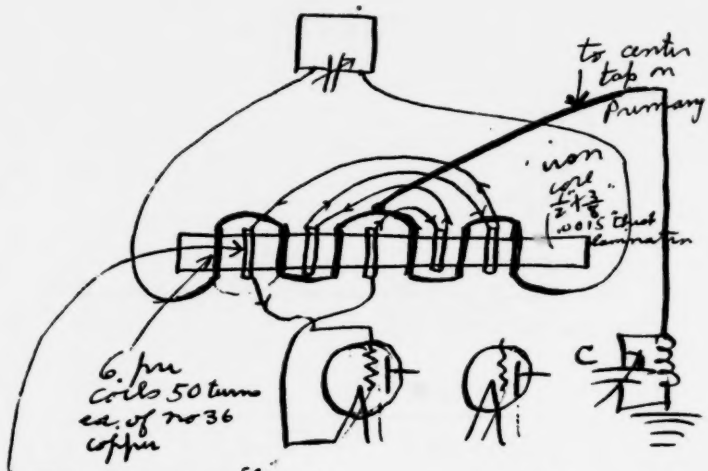
Apl 29 20

Unidirection using tap in center of coupling coil



PLAINTIFF'S EXHIBIT No. 26—Continued

25

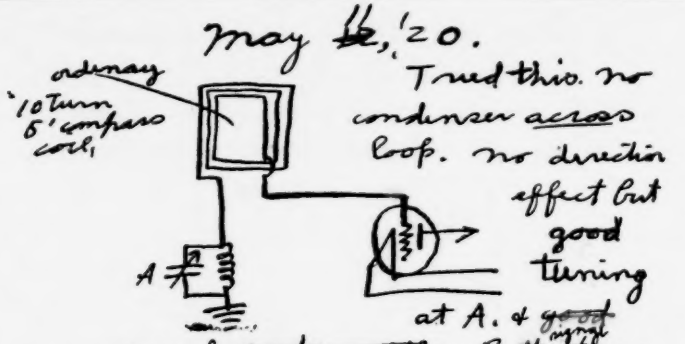


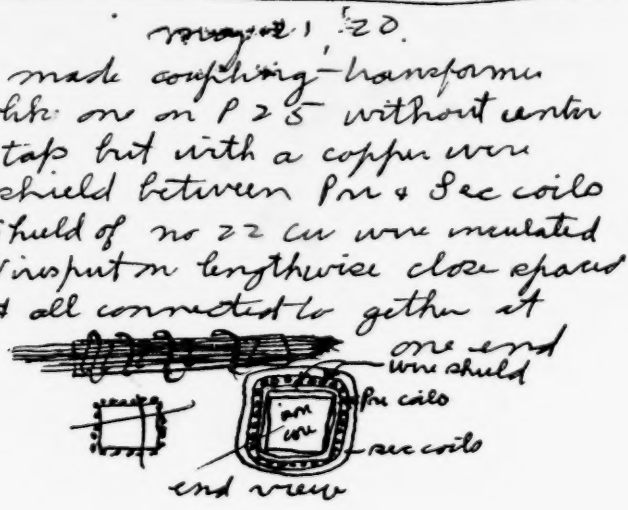
5 8 secondary coils 50 turns each of no 30 resistance wire 25.8 ω per ft

Tried this out. Found tuning at C not sharp but could set C & get good conduction on all 600 mile stations without any change in C, thus eliminating any fine or critical adjustment

PLAINTIFF'S EXHIBIT No. 26—Continued

26

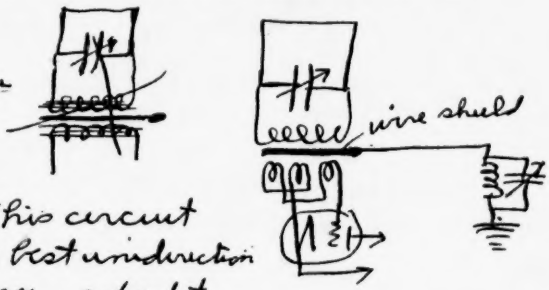




PLAINTIFF'S EXHIBIT No. 26—Continued

27

Found that by connecting the shield to earth thru tuning circuit I could get fine unidirectional results



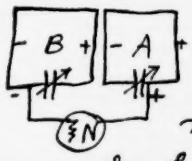
This circuit give best unidirection of any - except F A K method of tuning with balancing condenser. W Cunningham

PLAINTIFF'S EXHIBIT No. 26—Continued

28

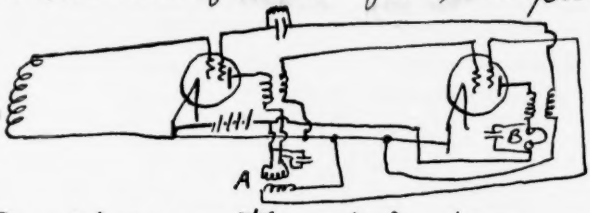
Dec 18 1920.

Method of using radio compass to get sharper maximum by using two coils. both tuned & rotated together coils at certain angle & detector connected across outside of each condenser.



Coils can be in same plane or at any angle with respect to each other note where tube is connected coils may also be rotated separately

new stunt - using two grid tube you can make amplifier with half the number of tubes for example :-



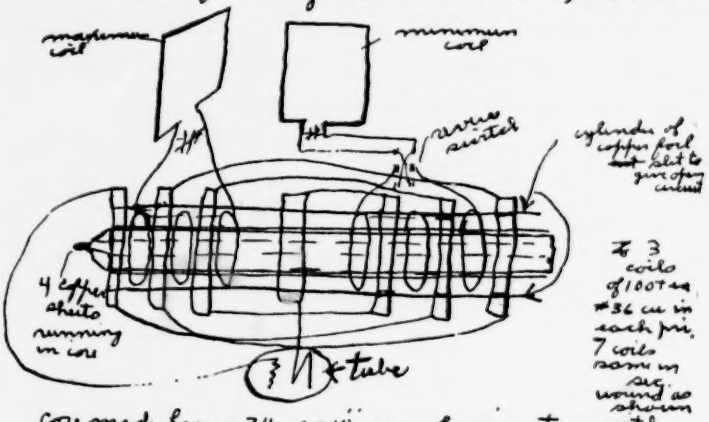
By adding another tube two more stages may be added

PLAINTIFF'S EXHIBIT No. 26—Continued

29

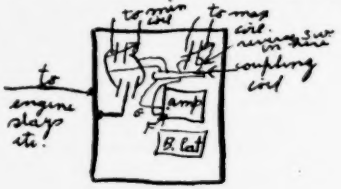
Jan 10. '21.

Method of using cross coils in plane



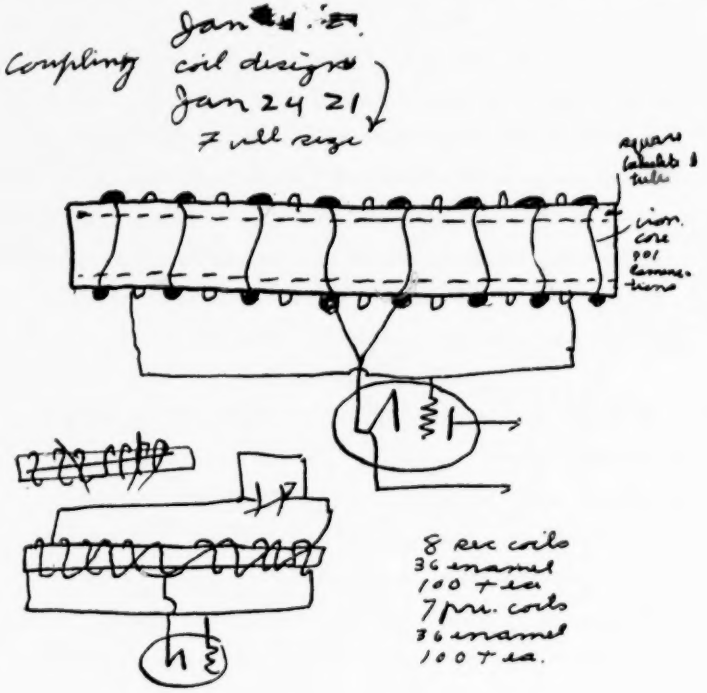
Core made from 24 .001" iron lamination with tissue paper between laminations

Tuning condensers ~~etc~~ amplifier balancing condenser etc all in shielded box, connected thus



PLAINTIFF'S EXHIBIT No. 26—Continued

30



PLAINTIFF'S EXHIBIT No. 26—Continued

31

Feb 10 '21.

From results of Scovill work with short wave radio amplifier stages it is evident that for short wave work (below 400m) it is imperative that all coils, condenser etc be so designed that there is a maximum of air dielectric, that is, space turns & cut away the material. Don't wind short wave windings right on iron core.

Feb ## 12, '21.

Got this circuit to working OK yesterday A plane can come up to field by radio, then without any other adjustment can pick up the audio induction from the field on radio coils the input going in the amplifier on detector tube, a the secondary of an audio transformer (shunted by a radio condenser) being in series with the secondary of the last radio stage & on the low potential side of the circuit is shown on next page & Engles note book also show results & circuits

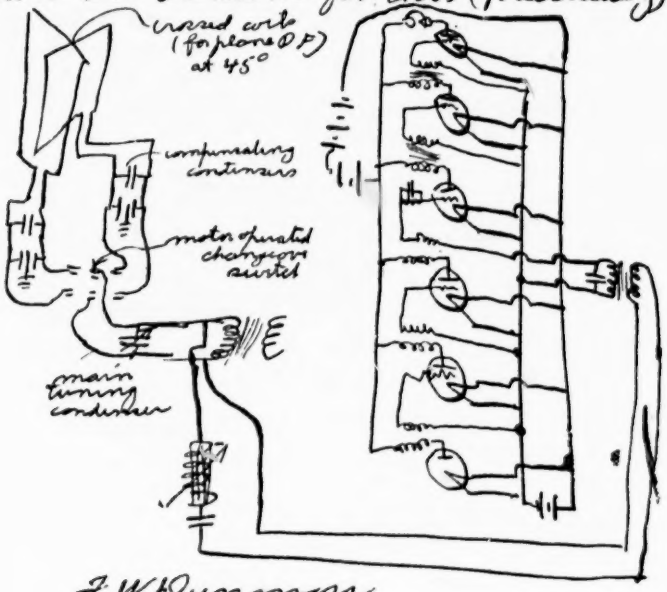
over

PLAINTIFF'S EXHIBIT No. 26—Continued

32

Feb 12 21.

This circuit is also applicable to ship D F's as they can use the D F coil to pick up "leader cable" (induction signal from cable in harbor) on same apparatus as they use for the radio on the D F. The drawings refered to on P. 31 which are given below are the same for this (practically)

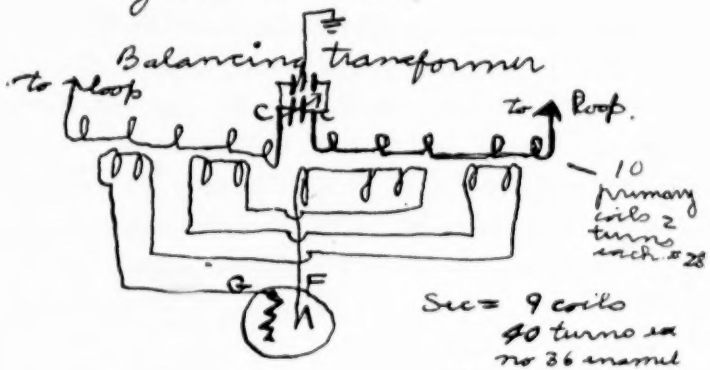


J W D

PLAINTIFF'S EXHIBIT No. 26—Continued

33

June 3 1921.



F W Dunmore
June 3 1921.

Francis W. Baer.

Witnessed this day June 3, 1921
Percival D. Lowell
June 3, 1921

PLAINTIFF'S EXHIBIT No. 26—Continued

34

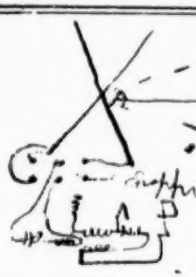
July 5 '21. Am thawi from my
thot of this (on June 28 '21) a
E.E.W. talked it over with me.
method of selective radio phone. Send
out an undamped wave. modulate
it with a super-audio undamped
wave. next modulate the super-audio
with a telephon modulator set. At
recv-g end tune to pure undamped
wave (= no sig) then tune also to
super-audio wave then w heaviside
. . . . . F. W. Dunmore

July 13. 21

Method of finding a plane or
ship etc - Transmit from two
crossed coils at 1 & 3" for example.
Use undamped & connect transmitting
tube or set pure into one coil & then
the other at a rate such as will
give an audible note at the
receiving end (plane etc.) We can
using a non oscillating tube
as amplifier for receiving

PLAINTIFF'S EXHIBIT No. 26—Continued

35



When on line A B when sigs from 2 coils are equal one will get a ~~beg~~ the highest pitched clear note. on A C it will be of ½ the frequency or noticably lower pitch. on A C'. to keep on course stay where pitch is highest

= W Dunmore
July 13. 21

July 19 21

Method of getting ground speed of airplane by radio interference method. Have two transmitting stations situated at a distance from each other. say ½ mile. Each sends on same λ & in phase by using synchronous current between stations to drive alternators. This will give interference bands at definite intervals along the plane's course the distance being

PLAINTIFF'S EXHIBIT No. 26—Continued

36

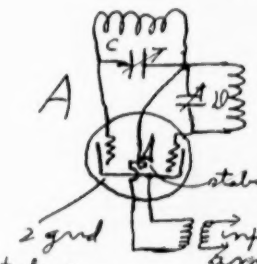
dependent on the λ used. Thus by timing the plane as these dead points are passed thus, & knowing the distance between them & the speed can be calculated

F W D

July 20 '21,

Static eliminator.

Sorell & I thought of this. Use two loops. ~~Set~~ connected as shown at A. By setting C on the signals minimum & (C & D same turns) D at any required position to get equal static as on C then the static being equal on the 2 grids will neutralize while the signal won't.

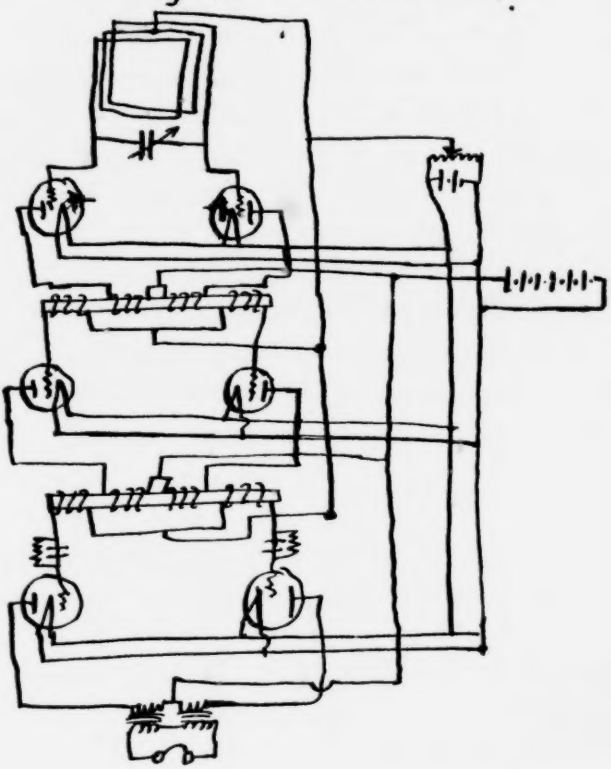


July 20 '21. F W D Wilmore

PLAINTIFF'S EXHIBIT No. 26—Continued

37

Amplifier July 26' 21.

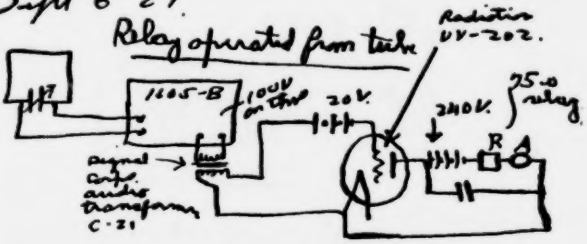


PLAINTIFF'S EXHIBIT No. 26—Continued

38

Sept 6 21.

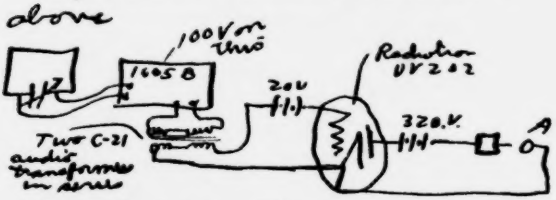
Relay operated from tube



F

With an average strength signal got change of 0 to 20 milliamps at A.

Sept 15 made additions to above



G

Got 0 to 30 milliamp change at A Decremeter 50 ft away would operate relay receiving on 4 ft loop.

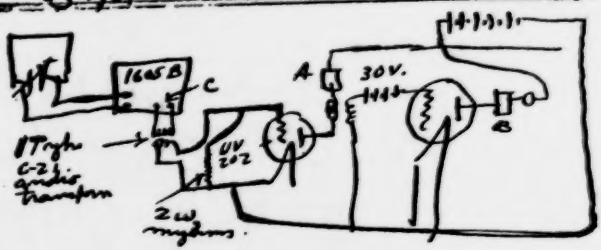
Sept 16 '21.

Put 2 UV-202's in parallel & got 0-40 milliamp change.

PLAINTIFF'S EXHIBIT No. 26—Continued

39

Sept 1921.



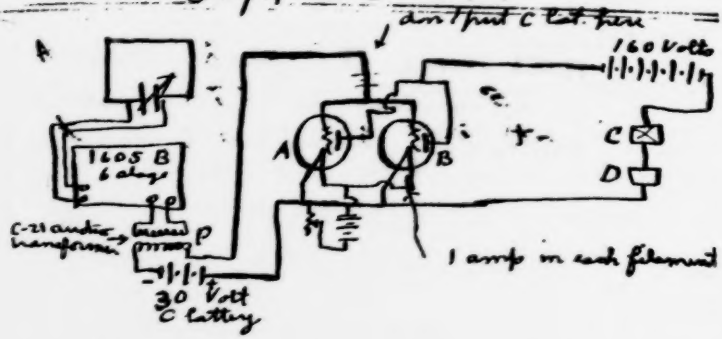
With best adjustment of above circuit could get 20 milliamps change at B for signal that was good comfortably readable

With 3 milliamps change at B, got 20 " " " " " C
" 3 "

PLAINTIFF'S EXHIBIT No. 26—Continued

40

Sept 23 21.



A & B 2 Radiotron amplifier tubes UV201

C = milliammeter

D = Ordinary relay rewound with no 38 copper S enameled SSC. 12000 turns. 1500 ohms.

C Battery adjusted to give 0 plate current when no signal comes in.

Relay will operate on 1 milliamp. It takes 4 milliamps to operate it when its turned up side down or side etc. Strongest signal will give 10 milliamps deflection. Our most sensitive setting (1 milliamp) it works on signal that you can just read at arms length with phone in series with Primary of P.

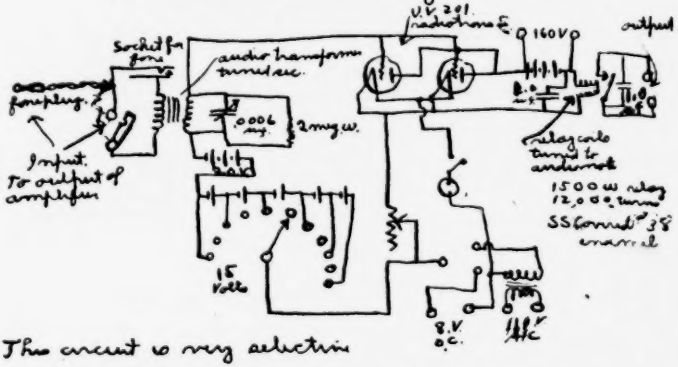
PLAINTIFF'S EXHIBIT No. 26—Continued

41

With no C bat. plate current is 18 milliamps. (T hrs is all with both tubes in circuit

Oct 7 '21

New data on relay recorder.



The circuit is very selective to audio frequency it being feasible to tune out a elm of slightly diffnt freqn due to diff beat note freqn. Two recorders could record simultaneously off same antennae.

F W D.

PLAINTIFF'S EXHIBIT No. 26—Continued

42

Data taken on 4 foot coil frame

½ inch spacing. Wave length range in metres obtained experimentally for various values of capacity across coil Terminals. moorhead detector tube across coil with tuning condenser across coil, thus  etc. No 20 DCC wire used

Wire turns spaced ½". Above 24 turns the winding is sectioned, & is wound with 2, 3, 5 or 10 conductors in each of 24 slots, as stated, the entire winding consisting of 24 groups being continuous not. Condensers having meas. capacity from .0005 to .003 microfarads may be expected to have a min C of approx .00004.

See next page.

PLAINTIFF'S EXHIBIT No. 26—Continued

43

number of Turns	condenser capacity for microfarads						Remarks
	.00005	.0001	.0005	.001	.002	.003	
1	52.	65.	128.	178.	250.	307.	
3	130.	155.	290.	400.	550.	675	
6	230.	280.	500.	710.	1000.	1200	
12	430.	490.	895.	1225.	1700.	2070	
24	760	880	1600	2100	3000	3600	
48	1500	1775	3150	4300	6000	7200	29 slots 2 turns per slot
72	2200	2650	4800	6400	8950	10900	29 slots 3 turns per slot
120	3930.	4500	7500	10400	14,420	17,700	29 slots 5 turns per slot
240	7,600.	9,000	15,150	20500	28300	34600	29 slots 10 turns per slot

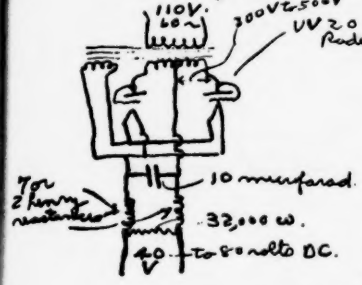
FOLDOUT(S) IS/ARE TOO LARGE TO BE FILMED

PLAINTIFF'S EXHIBIT No. 26—Continued

a 46

Dec 8 '21. Tube plate voltage from 60 to 1C

Set up this circuit & got it working OK. could use it for "B" battery voltage on a 6 tube amplifier. Snow Engl & Sowell intend on with this on amplifier.



Also found a one tube rectifier would work OK to give 160 volts for my recorder same circuit as above only the 32,000 ω resistance was not used. This gave 160 volts to 200 volts.

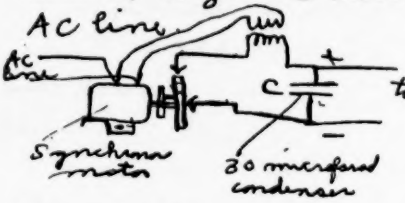
F. W. Dunmore

PLAINTIFF'S EXHIBIT No. 26—Continued

47

Dec 8 21.

Also at Snow suggestion I set up this circuit to give B battery voltage from AC line.



Commutator makes contact ~~xxxx~~ on + half of AC wave & charges condenser It is run slow so condenser is large & hold enuf to supply B battery current until next contact. Contact can be made less frequent the larger the condenser C. The circuit I set up didn't have synchronous motor but had the contactor wheel & a DC source. Get a little click in phones, but the frequency is so low it does not bother much Sowell, Snow Barr, & Engle saw this work

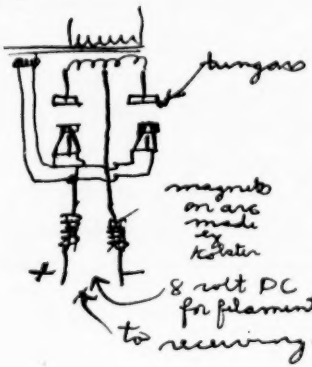
J W Dunmore

PLAINTIFF'S EXHIBIT No. 26—Continued

48

Dec 9. 21

Set up two tungars a rectified 60~ A C



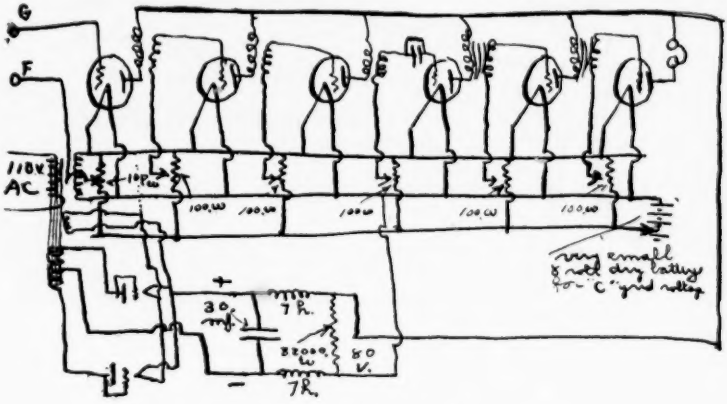
These gave com hum but with reg' one tube it was not bad

PLAINTIFF'S EXHIBIT No. 26—Continued

49

Dec 10 21

Receiving set worked from AC line
Filament & plate power supplied from same



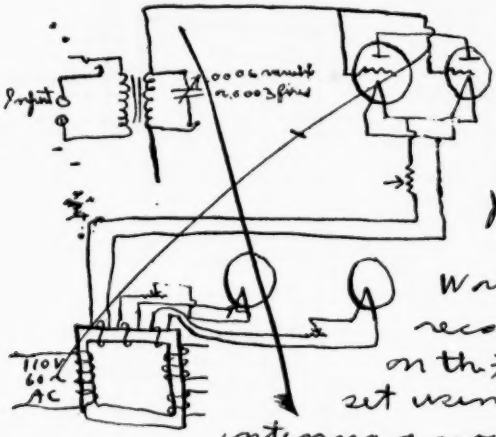
Tried the above only used
1 detector & 2 stages audio. It worked
but was insensitive. got most of
hum out

PLAINTIFF'S EXHIBIT No. 26—Continued

a
50

Dec 16, 21.

Set this circuit up yesterday & got it working OK today. Can work the recorder from the 110 V. AC line using the power for the A, B, & C battery so no batteries whatsoever are needed.



The circuit is given on the opposite page.

Worked the recorder OK on the French set using no antenna or ground & 1 stage of amplification. The following persons saw the recorder work.

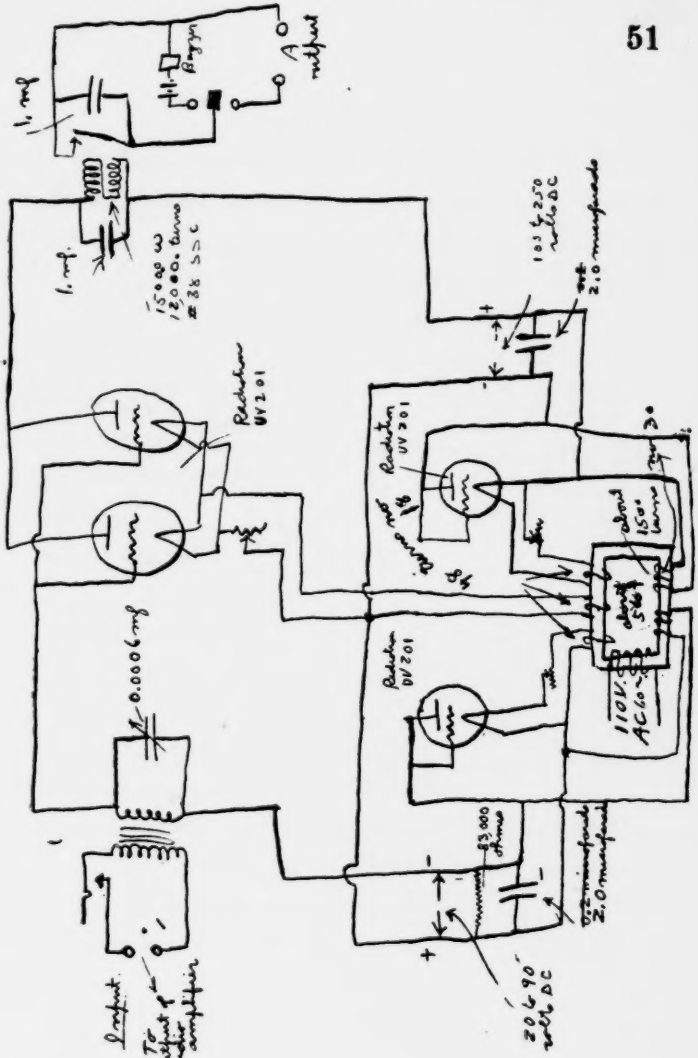
Morris S. Strock 12-17-21.

12/17/21. Francis X. Engel

F W Dunmore Dec 17 21.

PLAINTIFF'S EXHIBIT No. 26—Continued

51

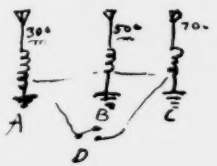


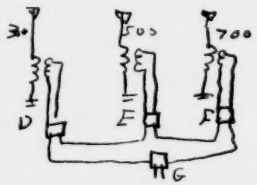
PLAINTIFF'S EXHIBIT No. 26—Continued

a
52

Jan 9 1922

means for getting selectivity in radio communication.





Let there be 3 or more undamped radio transmitters operated from a common key, each sending ~~from~~ on a different λ. Let there be 3 or more receivers each tuned to a different one of the λ's, each with a recorder with the recorder relay contacts in series. From ~~antenna~~ V. There is also a heterodyne or autodyne in each receiver the note of each being adjusted to the recorder audio tuned note. Now unless all 3 antennas are excited by their respective λ the 3 relays will not close. All 3 or more must close to operate O.

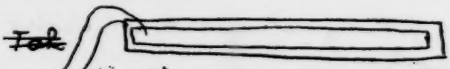
F W Dunmore Jan 9, 22.
P. D. Lowell Jan 19, 1922

PLAINTIFF'S EXHIBIT No. 26—Continued

53

Condenser design (PPL 10) .0003 mfds

~~Foil~~



$3\frac{1}{2} \times \frac{3}{8} \times .003$" varnished insulated paper (yellow) made by Irvington Varnish & Insulation Co. Irvington N J

$3\frac{1}{8} \times \frac{1}{4} \times .00?$ copper foil

Two such combinations are placed together & rolled up on a $\frac{1}{4}$" (dia) rod. This gives a condenser of approximately .0003 mfds.

8

PLAINTIFF'S EXHIBIT No. 26—Continued

56

makrum Relay.
8 thousand turns no 38 enamel
SSC wire on each coil.

Bunnell Relay.
11 thousands turns no 38 enamel
SSC wire on each coil.

PLAINTIFF'S EXHIBIT No. 26—Continued

PLAINTIFF'S EXHIBIT NO. 26—Continued

60

Jan 27 '22.

Set up part of circuit on P58-59. Used phone set on loop to transmit. Used two tubes oscillating at audio frequencies for the audio notes. The output of these tubes was plugged in place of the phone in the set, three modulation transformers used. I recorder & turned it to one pitch & other wouldn't work it. Then turned it to other pitch & the other wouldn't work it. Sent a mag on both pitches & either mag could be copied on the recorder tape. If I had had 2 recorders I could have gotten em both on tape at once. The following saw the work

J Weigel Jan. 27, 1922
F H. Rice Jan 27, 1922
P. D. Durell Jan 27, 1922

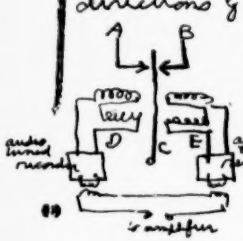
J W D unnecessary Jan 27 1922.

PLAINTIFF'S EXHIBIT No. 26—Continued

61

A method of remote control of radio

Set two crossed coil transmitters be arranged to send first one on one λ and then the other on a slightly different λ, the change from one coil to the other being rapid (30 cycles per sec or so). Receiving is done on the object to be controlled. One heterodyne is used which gives one note when signals are rec'd from 1 crossed coil & a different note when they are received from the other coil due to slightly different λ The audio output of the receiver goes thru 2 Duddell tuned relay recorders connected in series but each tuned to one of the audio notes. The two relays have a common armature so arranged as to be pulled in opposite directions by the 2 relay magnets. As the two audio keys are rec'd, first D pulls C & then E pulls C & the pulls are equal & opposite when the object to be controlled is on the equisignal line When it is off E (for example) pulls

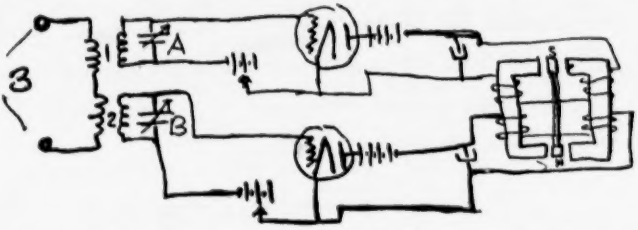


PLAINTIFF'S EXHIBIT No. 26—Continued

69

May 1 1922.

method of utilizing polarized relay on Wunmore type A. & B. recorder.



3 is the audio input from any suitable audio amplifier. The transmitter is of the undamped type & transmission is done by means of a spacer wave. Circuit A is tuned to the sending wave audio note & B to the spacing " " " (The reception being by auto or separate heterodyne

PLAINTIFF'S EXHIBIT No. 26—Continued

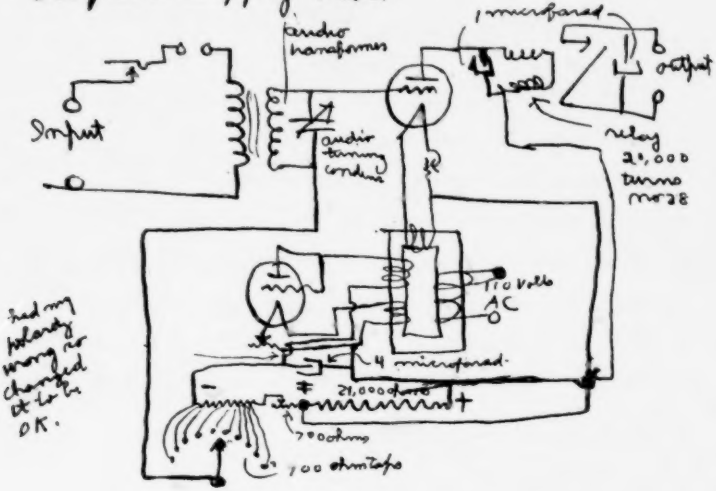
*

a 70

This should be June 5

May 5 1922

I mprovd relay recorder. I thought this up on the 3rd of ~~May~~ June 22 & showed the idea to Sowell. This idea gets rid of the grid voltage rectifier tube & gets the grid negative voltage from the plate supply tube.

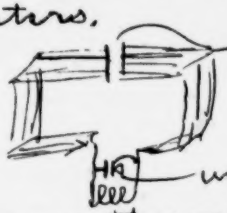


Disclosed to P. D. Sowell June 5, 1922

PLAINTIFF'S EXHIBIT No. 26—Continued

71

June 28 '22
method of modulation
in short wave transmission
around 100 meters.



transmitter connected as
follows thus throwing a transmitter
in & out of ~~tune~~ tune.

F W Dunmore

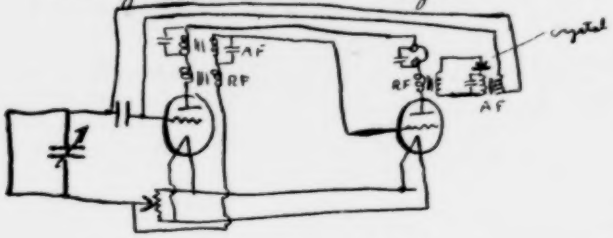
D sclosed to
P. D. Lowell
June 28, 1922

PLAINTIFF'S EXHIBIT NO. 26—Continued

a
72

June 28 22

2 stage radio 2 of audio
using 2 tubes & a crystal



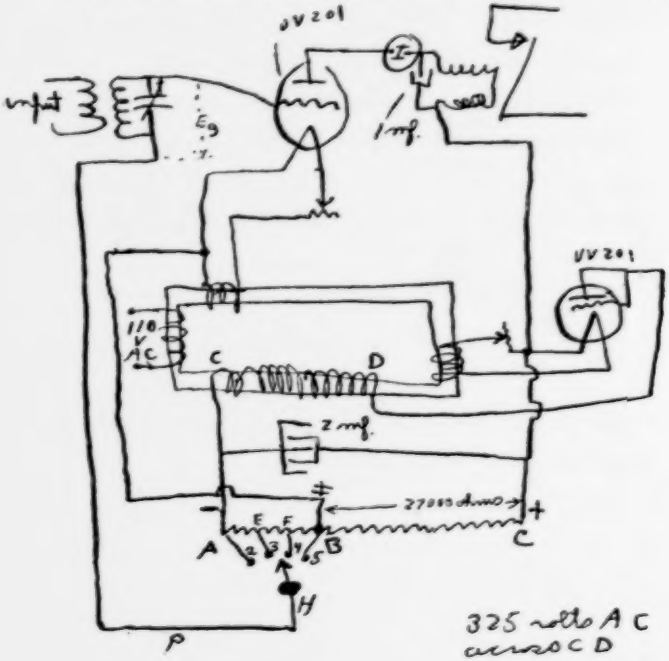
F W Dunmore

PLAINTIFF'S EXHIBIT No. 26—Continued

73

8 sept 2. 27

Hooked up the circuit on P 70
like this & it worked v. outside sigs.



325 volts A C across C D

230 volts across B C when I = 0

Hot 5 $I = 0$ $E_g = 0$
" 4 $I = 1.5$ $E_g = 39$ v.
" 3 $I = 0$ $E_g = 52$
" 2 $I = 0$ $E_g = 90$

AE, EF & FB are 35000 ohms each

There should be a variable resistance of 30 000 ohms at P. 7 W Dummore

PLAINTIFF'S EXHIBIT No. 26—Continued

74

Dec 1 22.

method of locating subs or metallic object by ~~a~~ searching with a mirror reflector operating at short λ's vary the source ∴ focus distance till its focused on object. When it hits object it will put load on generator

source: 10 metres or some such λ.

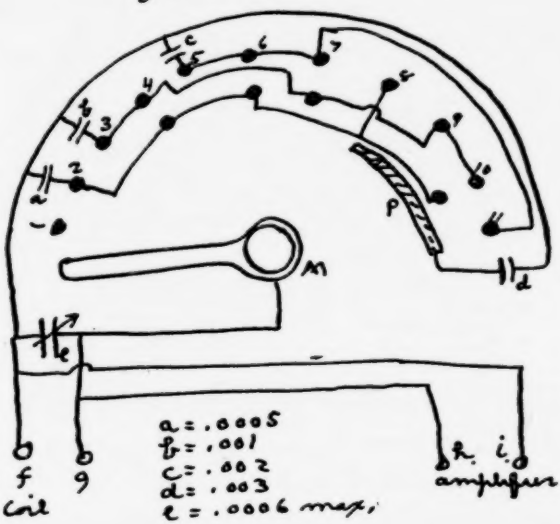
as C is moved F moves until it falls on object.

Can use this stunt as D.C. to get direction & distance with <u>one</u> reflector.

PLAINTIFF'S EXHIBIT No. 26—Continued

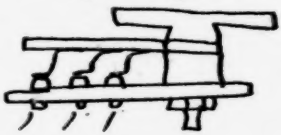
75

Copied from Radioelectricité
Jan 1923.



1	e	0 - .0006
2	e + a	.0005 - .0011
3	e + b	.0010 - .0016
4	e + a + b	.0015 - .0021
5	e + c	.0020 - .0026
6	e + a + c	.0025 - .0031
7	e + b + c	.0030 - .0036
8	e + d + a	.0035 - .0041
9	e + d + b	.0040 - .0046
10	e + d + a + b	.0045 - .0051
11	e + d + c	.005 - .0056

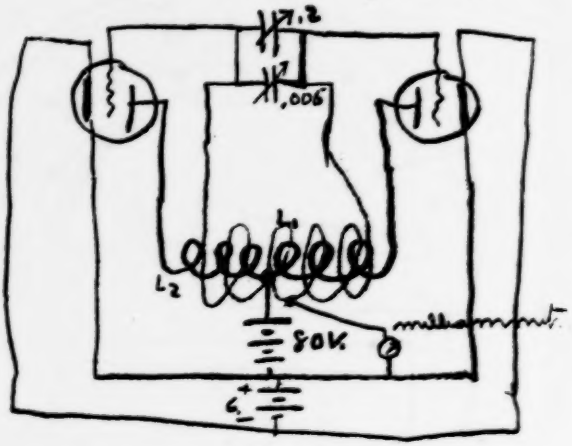
this will give with 1 meh square coup with 60 turns a range of 2400 - 17,000.



PLAINTIFF'S EXHIBIT No. 26—Continued

76

From L'ONDE Electrique
march 1923
45 - 70 metre generator



L_2 9 turns on 8 cm dia cylinder.
L_2 7 turns wound right over L_2 with insulation between.

PLAINTIFF'S EXHIBIT NO. 27

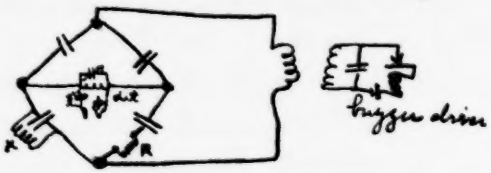
LOWELL LABORATORY NOTEBOOK

21

Jan

Mon 9 1922

Did some work on H. F bridges.



With coil X and resistance R out of circuit, good balance was obtained. It was found however that with coil X in as it would be connected when measurements are to be made and that with the buzzer driver set at or near the wavelength of coil X and its conclusion that the good balance was destroyed upon inserting resistance R when R is more than 10 ohms.

When the buzzer is operated at a widely different wave length, the balance is obtained nicely.

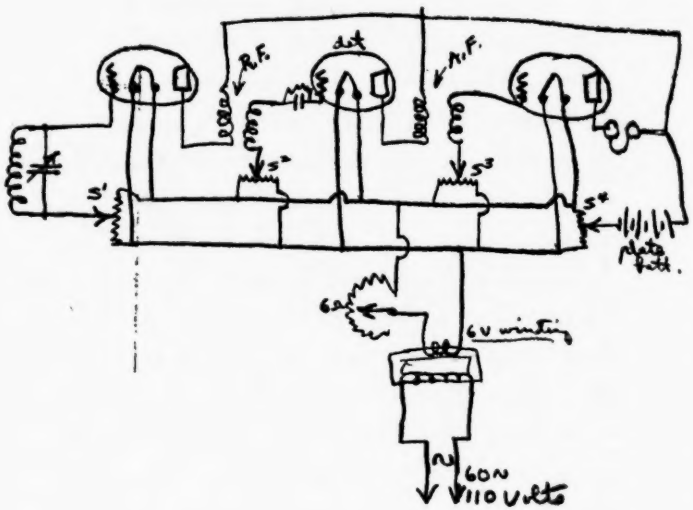
PLAINTIFF'S EXHIBIT No. 27—Continued

22

Tues
Jan 10
1922

Took up some experimental work in attempt to work tube receiver on 60 cycle supply for filaments and plates. Tried it on filaments only at first.

First tried 1 radio freq. stage detector and 1 audio stage as shown below.



PLAINTIFF'S EXHIBIT No. 27—Continued

23

It was found that ~~s1~~ grid potentiometers $S^2 + S^3$ helped greatly in reducing 60 ~ hum by virtue of keeping the normal voltage on the grids at zero.

S^1 did not produce any results so it is presumed that the R.F. transformer effectually blocks any 60 ~ frequency pulsed from getting thru to detector.

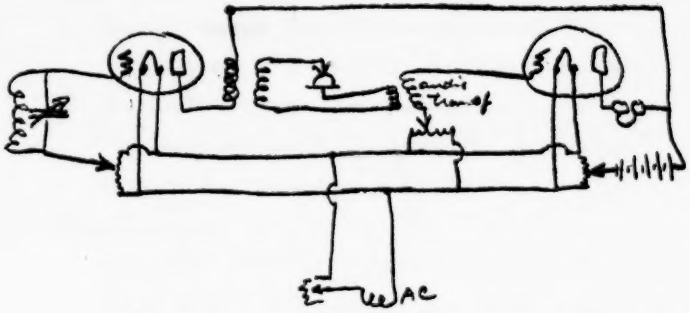
S^4 was used to prevent any variation in plate voltage due to 60 ~ filament supply.

The above circuit was quite full of 60 ~ hum although radio signals were received with it. A galena crystal detector was used in place of the tube detector and connected as shown below.

over

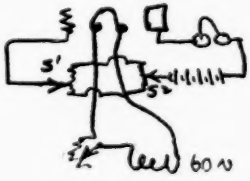
PLAINTIFF'S EXHIBIT No. 27—Continued

24



This gave very good operation and was almost free from 60 ~ hum. It was thought that the residual hum was due to some other source other than variation in grid voltage because the grid biasing rheostat should keep the grids at zero voltage.

The following circuit was tried to test this assumption.



PLAINTIFF'S EXHIBIT No. 27—Continued

25

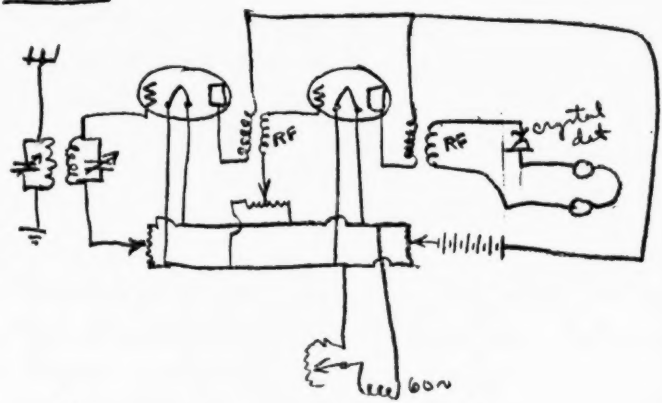
Grid connected directly to filament thru potentiometer 5' ~~thru~~ and on varying 5' a point is found where the 60 ~ hum dies out almost entirely but not quite thus showing that the remaining hum is due to something other than its effect on the grid ~

PLAINTIFF'S EXHIBIT No. 27—Continued

26

Wed Jan 11 1922

The following circuit was set up.

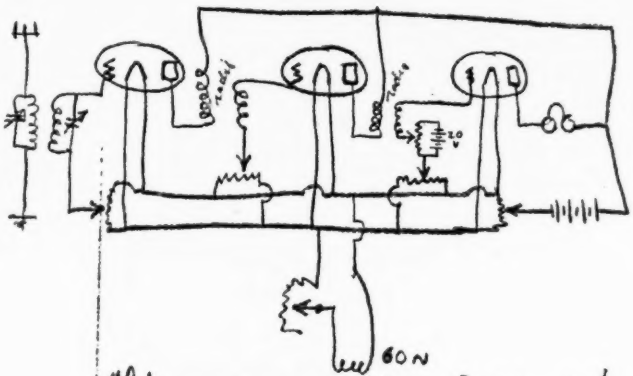


Consists of 2 R. F. stages and crystal detector. This circuit is by far the best yet tried and seems to indicate that 3 or 4 R.F. stages may be used and a crystal detector

PLAINTIFF'S EXHIBIT No. 27—Continued

27

A tube detector was tried again but connected without grid condenser and leak, the rectifying action being obtained by making the grid about 15 volts negative. Sketch below.



This gave a quieter circuit with less hum than the ordinary grid condenser detector circuit but the detector action is not as good.

So far, it seems that R. F. amplification with a crystal detector gives best results.

It was thought that a

PLAINTIFF'S EXHIBIT No. 27—Continued

28

telephone transformers with
a 1 to 1 ratio between the
detectors and plates might help
but it was found to be no
improvement.

PLAINTIFF'S EXHIBIT No. 27—Continued

29

Thurs Jan 12 1922

Spent all morning writing outline for Dr. Dellenger on proposed procedure in bridge and amplifier work.

Don't know just what to do next on bridge problem so will wait till Mr. Cox comes again and will follow his suggestions.

Some more circuits were tried in the amplifier to reduce the hum due to 60 ~ on filaments, especially when a tube detector is used. Although the circuit employing 2 radio frequency stages and crystal detector operates with a minimum hum it is considered very bad to have to use a crystal detector and further tests will be made so that a tube detector may be used if possible.

PLAINTIFF'S EXHIBIT No. 27—Continued

30

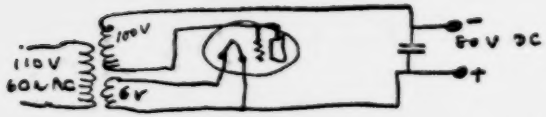
A tube detector was tried again and various schemes tried to balance out the residual hum by feeding or inducing a back emf both into the grid and plate circuits but no further success was attained.

PLAINTIFF'S EXHIBIT No. 27—Continued

31

Friday Jan 13 1922 Went back to the two radio stages and crystal detector and put on one audio stage. The audio stage produced somewhat more of a hum.

Next tried A.C. as source of plate voltage by rectifying about 80 volts with a electron tube (Moorhead) acting as rectifier. This rectified pulsating D.C. was smoothed out by means of a 20 microfarad condenser across the output. The standard rectification circuit was used (see diagram below)



The amplifier worked fairly well with this source of plate voltage but the residual hum

PLAINTIFF'S EXHIBIT No. 27—Continued

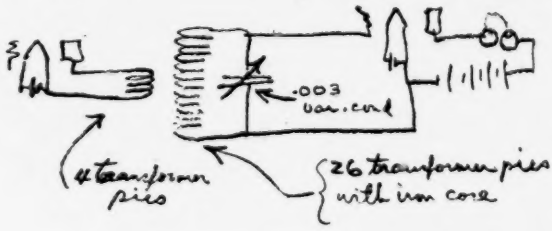
32

due to the A.C. filament current affecting the grids was quite bad.

Think that this source of plate voltage is satisfactory but something must be done to get rid of the hum caused by A.C. on filaments.

Will try a Tungar rectifier to give D.C. for filaments next.

Helped Mr Dunmore on some audio frequency tuning work. Used an audio stage made up of transformer secondary sections so as to have low resistance and give better tuning.



PLAINTIFF'S EXHIBIT No. 27—Continued

33

This gives quite sharp A.F. tuning and may be useful in Mr. Dunmore's work on recorder.

34

Sat. Jan 14 1922 — Wrote reports all morning (notebook – weekly – monthly)

On leave in afternoon.

PLAINTIFF'S EXHIBIT No. 27—Continued

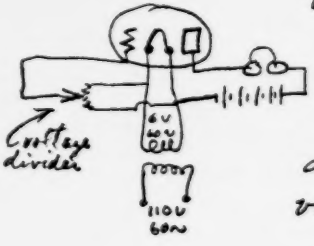
35

Mon Jan 16 1922

Talked with Mr. Cox on H.F. bridge work. He seemed quite pleased with the progress made and said he would have the bridge arm condensers calibrated and then some actual measurement tests will be made.

Mr. Dunmore and I continued work with the amplifier circuits in the attempt to ~~[illegible]~~ use the 60 cycle power for filaments and plates.

As was stated before, with the simple circuit shown below—



it was found that the 60 cycle hum could be balanced out by adjusting the voltage divider

PLAINTIFF'S EXHIBIT No. 27—Continued

36

on the grid, which means that the ~~grid~~ normal grid voltage is at zero with respect to the filament at all times.

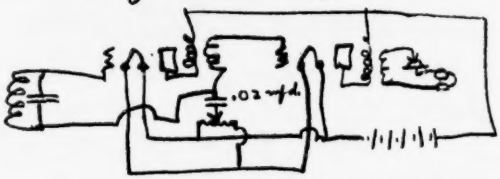
But there is still a residual hum left which has a 120 cycle frequency. This is ~~evidently~~ due to the change in plate current ~~=~~ with the change in brilliancy of the filament. The filament becomes brightest at two times during the A.C. cycle once positive and once negative. Therefore the plate current rises ~~and~~ and falls synchronously giving the double frequency of 120.

PLAINTIFF'S EXHIBIT No. 27—Continued

37

Tues Jan 17 1922

It was found that the R.F. amplification could be considerably increased by inserting a condenser of about .02 microfarads in series with the slider on the voltage divider, thus:—



This evidently allows the grid voltage to assume a more favorable voltage for amplification while the voltage divider prohibits any A.C. emf. from affecting the grids.

An audio frequency stage may be added after the crystal detector but with considerable increase in hum. The hum, however can be materially reduced by introducing

PLAINTIFF'S EXHIBIT No. 27—Continued

38

of about .02 mfd.
a series condenser shunted by
an 80,000 leak, in series with
the plate and telephone circuit.
This condenser seems to
obstruct the path of the 120
cycle hum while the higher
frequencies pass through.
The 80,000 leak allows the
plate voltage to bypass the
condenser and reach the plate.
It was also found that
a condenser of about .02 mfd
in series with the grid voltage
divider improved the amplification.
This allows the grid to assume
a better voltage for amplification
instead of being held at zero by
the stabilizer -

PLAINTIFF'S EXHIBIT No. 27—Continued

39

Wed Jan 18 1922 Have practically given up hopes of using a tube detector because of the bad hum present when it is used.

When a tube detector and one audio stage is used, the 120 ripple in the detector plate is amplified by the audio stage and increased to a great degree. But with a crystal detector, there is no 120 ~ hum impressed on the grid of the audio tube and therefore the only hum left is that which is in the plate circuit of the audio frequency amplifying tube.

A rectifying circuit is being set up for producing rectified A.C. for the filament supply. For this purpose one Tungar bulb will be used.

PLAINTIFF'S EXHIBIT No. 27—Continued

40

Thurs Jan 19 1922

The Tungar rectifier circuit was completed and the amplifier tried with the rectified A.C. on the filaments.

It was found that the hum was much worse than when pure A.C. is used on the filaments. Evidently, when the A.C. is rectified, the wave form becomes unsymetrical thus:

~~This wave form therefore prevents the~~ With this form of current on the filaments therefore, it becomes impossible to stabilize its effect upon the grids by means of the ~~stabilizer~~ dividers and the hum cannot be eliminated to any great extent.

PLAINTIFF'S EXHIBIT No. 27—Continued

41

Fri. Jan 20 1922

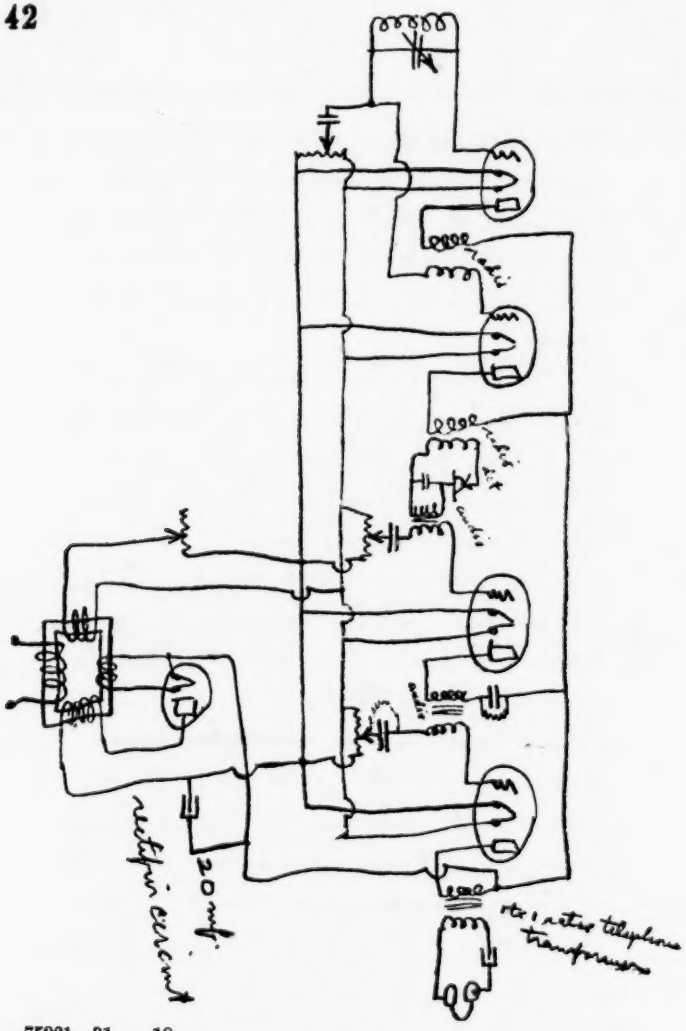
Think it is more advantageous to use pure A.C. on the filaments as the hum can be more nearly eliminated.

Tried a circuit with two radio frequency stages, crystal detector and two audio stages with pure A.C. on filaments and rectified A.C. on the plates. Used the following circuit.

see next page

PLAINTIFF'S EXHIBIT No. 27—Continued

42



PLAINTIFF'S EXHIBIT No. 27—Continued

43

The circuit diagram shows condensers of about .02 microfarad in grid circuits of A.F. amplifier tubes and a leak of about 500,000 ohms across the condenser in the second A.F grid.

On the plate circuit of the 1st A.F. tube is an .02 condenser shunted by 80,000 resistance, the condenser partially blocks the 120 cycle ripple and the 80,000 leak bypasses the plate voltage to the plate. The telephones are coupled into the 2nd A.F plate circuit by a 1 to 1 ratio telephone transformer. [redacted] condenser, about .001 mf. is in series with phones in secondary circuit. This condenser as well as the transformer itself helps to block out the 120 cycle hum.

The rectifier for the plate voltage

PLAINTIFF'S EXHIBIT No. 27—Continued

44

is shown with a 20 mfd condenser across the D.C. output. This smoothes out the rectified voltage and makes is very suitable for use on the plates. There is practically no hum with ~~A.C.~~ rectified A.C. on the plates.

The 60 cycle transformer shown has 4 windings, one for the 110 volt input, one for the amplifier filaments, one for the rectifier filament and one for the plate voltage supply.

This complete circuit works quite well, although there is some hum present, it is not very objectionable. The crystal detector, however is the great drawback and its use of course is very undesirable and improper.

It is still hoped, however that the use of a tube detector

PLAINTIFF'S EXHIBIT No. 27—Continued

45

is still possible without objectionable hum. Further schemes will be tried for its use.

Sat
Jan 21 Assisted Mr. Dunmore on
1922 some work with his recorder.
Wrote in notebook. On leave
from 3:00 o'clock

PLAINTIFF'S EXHIBIT No. 27—Continued

46

Mon. Jan 23, 1922

Dunmore and I tried a Magnavox loud speaker in conjunction with the amplifier, both amplifier and Magnavox being run on the 110 volt 60 cycle power.

The amplifier circuit shown on page 42 was used and the direct current for the Magnavox field coil supplied from A.C. rectified by a Tungar rectifier tube.

Did not get good results for some unknown reason, there being a loud hum always present.

PLAINTIFF'S EXHIBIT No. 27—Continued

47

Tues Jan 24 1922

Found a faulty connection in amplifier circuit and when this was fixed the amplifier + magnavox worked very nicely, there being some 60 ~ hum present but not objectionable. A 55 volt winding was used on the transformer this being rectified by a Tungar and when applied to Magnavox field coil fell to about 4 volts, the large inductance of the field coil serving to smooth out the rectified A.C.

Helped Mr. Dunmore on some recorder tests.

PLAINTIFF'S EXHIBIT No. 27—Continued

50

Thurs Jan 26 1922

The complete circuit disclosed on page 49 works very nicely there being a negligible amount of hum present which is not objectionable. Radiophone speech and music was picked up from several places and reproduced with as much clearness as when batteries are used throughout.

Of course the crystal detector is objectionable in a way, but the fact that the radio frequency amplification before it produce a large e m f upon it reduce this objection considerably. It was found that almost any old crystal operated well because of the large e m f impressed upon it, making it more efficient in operation.

It is thought advisable to have two sets made in the

PLAINTIFF'S EXHIBIT No. 27—Continued

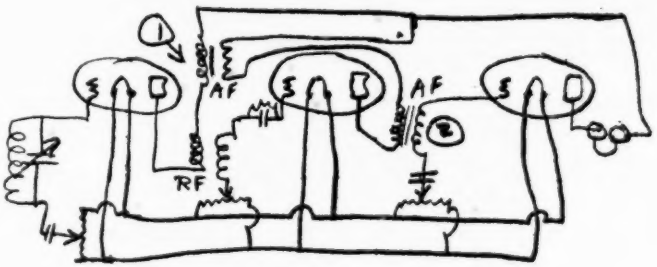
51

shops. One radio-audio frequency amplifier with its transformers and rectifier tube and one Magnavox set with 2 audio power stages, transformers, Tungar rectifier and loud speaking magnavox for the convenience of the laboratory, when it is desired to transport a receiver and loud speaker to any place for demonstration purposes or for exhibitions such as was given by the Bureau some time ago.

PLAINTIFF'S EXHIBIT No. 27—Continued

52

Friday Jan 27 1922 Made a few more trials at using ~~a~~ electron tube ~~detector~~ in place of the crystal. I thought that the following circuit might help out.



audio frequency transf. (1) in plate of R.F. tube to pick up hum which is fed into plate circuit of A.F. tube into A.F. transf. (2). The two hums should buck out if connected properly.

This did not help any so have given up idea of using tube detector.

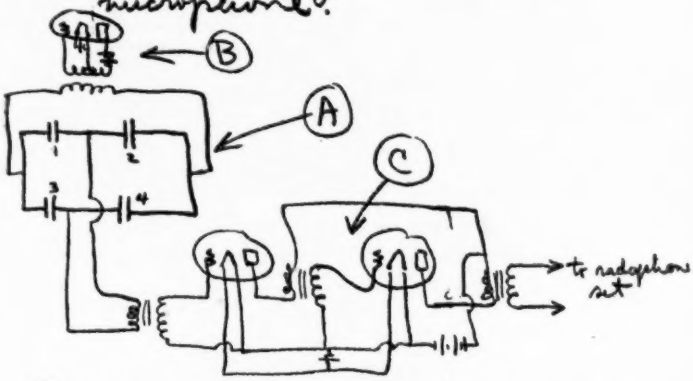
PLAINTIFF'S EXHIBIT No. 27—Continued

53

Sat Jan 28 1922

Helped Mr. Dunmore with his recorder experiments.

Doped out a modulating circuit using a condenser microphone.



(A) is a H.F. bridge circuit wherein any one of the condensers 1, 2, 3 + 4 may be a condenser microphone. (B) is a H.F. generating circuit coupled to input of bridge. The output of bridge goes to audio frequency amplifier (C) and thence to radio phone set. When bridge is balanced, any variation of one of the condensers 1 - 2 - 3 or 4 such as caused by

PLAINTIFF'S EXHIBIT No. 27—Continued

54

the speech, allows the RF from (B) to get into the A.F. amplifier (C), this R.F. being modulated according to the speech.

Conferred with a visitor regarding some receiving circuits.

Helped Mr. Dunmore on some recorder tests.

PLAINTIFF'S EXHIBIT No. 27—Continued

55

Mon Jan 30 1922	Started on design for 5 tube amplifier worked on 60 A.C.
Tues Jan 31 1922	Started shop drawings for A.C. amplifier.
Wed Feb 1 1922	Worked on shop drawings for A.C. amplifier.
Thurs Feb 2 1922	Mr. Buckley took over work on drawings for A.C. amplifier. Helped Mr. Dunmore on tests with problem of sending two messages on one wave length by means of two audio frequency notes working two recorders.

PLAINTIFF'S EXHIBIT NO. 27—Continued

56

Fri Feb 3 1922 — Helped Mr. Buckley on drawings for A.C. amplifier.
Made some practical tests with A.C. amplifier. Figured on arrangement of apparatus for transformer and rectifier unit to go with A.C. amplifier.
Conferred with Dr. Brooks regarding construction of 60 ~ A.C. transformer for A.C. amplifier.

Sat. Feb 4 1922 — Conferred with Mr. Buckley regarding details of A.C. amplifier drawings.
Made some tests with rectified A.C. on field coil of Magnavox. Find that about 100 volts A.C. when rectified with Tungar gives about proper current thru Magnavox.

PLAINTIFF'S EXHIBIT No. 27—Continued

57

Mon Feb 6 1922	Worked with Mr. Buckley on drawings for A.C. amplifier. Trying to make set as compact as possible and portable. Will be ready for mechanician to start about Thursday this week. Assisted in tests with Dunmore's recorder. F.W.D and Baer at latter's home, receiving and I at Bureau sending. Tests not very satisfactory due to faulty transmitter.
Tues Feb 7 1922	L.E.W., F.W.D., J.A.W. and I conf. re. short wave transmitting and receiving problem for Signal Corps. Experimented with various transformer windings for Tungar filament. Found about a 3 volt heavy current winding satisfactory. Tried various windings for amplifier filaments but found no

PLAINTIFF'S EXHIBIT No. 27—Continued

58

Attended Mr. Whittemore's talk on Radio Broadcasting

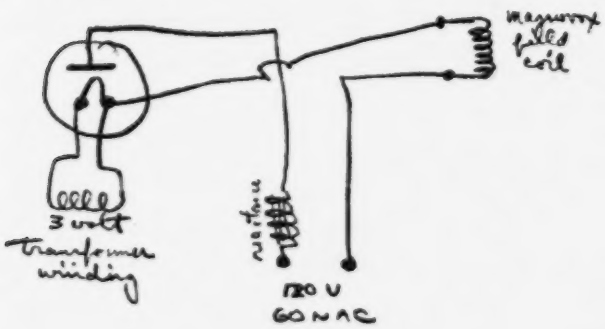
difference in amount of A.C. hum produced.

Worked with Mr. Buckley on drawings, nearly completed.

Wed Feb 8 1922

Tried various voltages on Tungar plate to be rectified for Magnovox field coil, trying to get 6 volts D.C. into same.

Found that 120 volts A.C. applied directly to Tungar with reactance in series gave proper results. Circuit:—



PLAINTIFF'S EXHIBIT NO. 27—Continued

59

This gave about 100 volts A.C. input to Tungar and about 40 volts pulsating D.C. output.

When the high impedance field coil of the Magnavox is connected on, the pulsating D.C. is smoothed out and 6 volts D.C is left across field coil which gives the proper operation of the Magnavox with only a slight hum due to the semi-pulsating D.C. on the Magnavox field coil

Conferred with Mr. Danford & magnetic section regarding design of transformer for Magnavox amplifier.

PLAINTIFF'S EXHIBIT No. 27—Continued

60

Thurs Feb 9 1922

Made a transformer according to specifications of Mr. Samford, magnetic section.

Transformer has five windings as follows:—

550 turns #20 — primary for 1100 - 60 ~ AC
2000 " #30 — 400 volts for plates
40 " #18 — 8 volts for amplf. fils.
40 " #20 — 8 volts for plate rectifier tube filament.
25 " #12 — 5 V for Tungar filament.

D.C.C. copper wire used on all windings except the 2000 turn coil which has single silk over enamelled copper wire.

Core of silicon steel 3 centimeters square in section and 3 inches × 4½ inches square, inside measure.

This transformer gave very good results. By varying the brilliancy of the plate rectifier

PLAINTIFF'S EXHIBIT NO. 27—Continued

61

tube a range in D.C. plate voltage of from 40 to 400 volts can be obtained.

Friday Feb 10 1922 Started design for rectifying unit for A.C. amplifier and Magnavox. Unit will contain A.C. power transformer plate voltage rectifier tube and 12 mfd. condenser, Tungar tube rectifier and filament control rheostat. All will be contained in a closed box which will be easily carried and provided with a lamp cord and plug for connecting to A.C. power mains.

~~Meeting~~ Certain meeting in P.M.

PLAINTIFF'S EXHIBIT No. 27—Continued

62

Sat Feb 11 1922.

Tried some tests with Magnavox, 1 and 2 stages audio frequency amplification and microphone on the input. It was found that the ordinary audio frequency transformers produce considerable speech distortion due to their rather sharply tuned characteristics.

General Radio modulation transformers gave much better tonal values.

It is thought that a transformer of special design will be better or possibly a resistance coupled type of audio frequency amplifier.

PLAINTIFF'S EXHIBIT No. 27—Continued

63

Mon Feb 13 1922 — Wrote up report for publication on A.C. amplifier. Tried out two stages of resistance coupling for audio frequency amplification. Used French type 80,000 ohm coupling resistances and 0.02 microfarad coupling condensers.

This type of coupling gave very good quality in speech or music amplification but with not as much amplification per stage as transformer coupling, which is to be expected.

Tues Feb 14 1922 — Worked on shop drawing for rectifier unit to go with A.C. amplifier. This unit to include power transformer, plate rectifier tube, Tungar rectifier tube, smoothing out condenser of 10 microfarads and filament rheo for plate rectifier tube.

PLAINTIFF'S EXHIBIT No. 27—Continued

64

Wed Feb 15 1922 On leave all day

Thurs Feb 16 1922 Conferred with Ould on publication of report on A.C. amplifier.

Made 10 circuit diagrams for him to go with report.

Changed filament windings on power transformer for A.C. amplifier, they had too many turns on them.

~~Looked up~~ Investigated catalogs for purpose of ordering some parts for A.C. amplifier.

PLAINTIFF'S EXHIBIT No. 27—Continued

65

Fri Feb 17 1922 — Worked on shop drawings for A.C. rectifier unit for amplifier. Went downtown to Amateur Radio Convention in afternoon

Sat Feb 18 1922 — Made a few more tests with A.C. amplifier set-up using modulation transformers in A.F. stages. Modulation transformers gave better quality amplification on radiophone speech and music but not ~~[illegible]~~ so much amplification of signals. Tried choke coils in series with plate voltage supply on D.C. side of rectifier tube. They helped some to eliminate hum in telephone receivers.

PLAINTIFF'S EXHIBIT No. 27—Continued

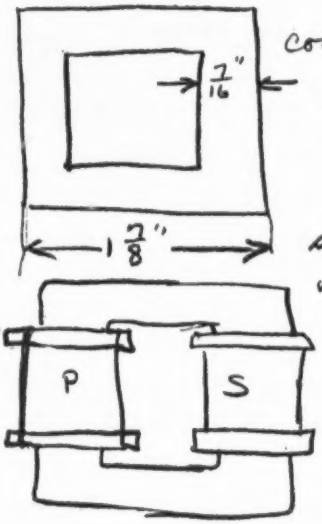
66

Mon Feb 20 1922	Started on construction of A.C. amplifier. Got together all necessary parts available. Got bakelite from Preston and Signal Corps for panels and shelf. Cut and drilled top panel. 5 hours in shop.
Tues Feb 21 1922	Worked on A.C. amplifier construction in shop. About 6 hours.
Wed Feb 22	Holiday
Thurs Feb 23	On shop on A.C. amplifier work. About 6 hours.
Friday Feb 24	Worked in shop on A.C. amplifier Mounting transformers, sockets and other parts. About 6 hours

PLAINTIFF'S EXHIBIT No. 27—Continued

67

Sat. Worked in shops on I.C.
Feb 25 amplifier. Assembling and
1922 mounting parts.
about 6 hours.
Made new telephone transformer.



Pri + Sec wound on square bakelite tube on opposite legs. Tube 1/2" square inside wound with 2000 turns #38 enamelled copper wire on each coil.

PLAINTIFF'S EXHIBIT No. 27—Continued

68

Mon Feb 27, 1922 — Worked on A.C. 1 amplifier in shop assembling and mounting. About 5 hours

Tues Feb 28 1922 — Continued shop work on 1 A.C. amp. about 2 hours. On leave rest of day.

Wed Mar 1 — Finished shop work on A.C. amplifier unit. Rectifier unit still not made.

Thurs Mar 2 1922 — Started wiring up A.C. amplifier.

Fri Mar 3 — Finished wiring A.C. amp.

PLAINTIFF'S EXHIBIT No. 27—Continued

69

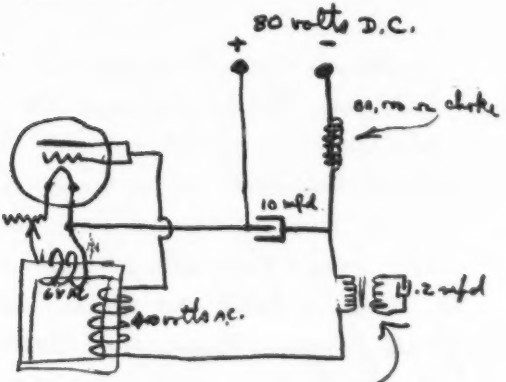
Sat Mar 4 1922	Made tests with finished A.C. amps. Encountered much hum. Spent time trying to make it work properly.
Mon Mar 6 1922	Worked with amps. trying to get hum out. Checked over wiring. Tried battery on filament and rectified A.C. on plates. Still much hum so must be coming from A.C. on plates.
Tues Mar 7 1922	Worked with battery on filaments and tried to quiet down rectified A.C. on plates. Found several smoothing out condensers in bad shape. Put additional choke coil in plate line. Finally got much better results.

PLAINTIFF'S EXHIBIT No. 27—Continued

70

Wed Mar 8 1922 Discovered a method to limit the D.C. output of plate rectifier which keeps D.C. plate voltage at 80 volts, regardless of brilliancy of rectifier tube filaments.

Circuit :—



Secondary of audio frequency transformer in here seems to act as a voltage limiting device, keeping D.C. output voltage at 80 volts regardless of rectifier tube's filament temperature.

PLAINTIFF'S EXHIBIT No. 27—Continued

71

Thurs Mar 9. Worked more with eliminating hum in amplifier. Rectified A.C. seems to be OK. now. Still some hum when A.C. is used on filaments but not objectionable

Fri Mar 10 1922 Made some more tests with A.C. on both filaments and plates. Took some turns off filament windings of power transformer as fils. were too bright. Amplifier seems to be about as quiet and free from hum as could be expected.

Sat. Mar 11 1922 Continued testing out A.C. amplifier. Started writing report on R. F. amplifiers.

PLAINTIFF'S EXHIBIT No. 27—Continued

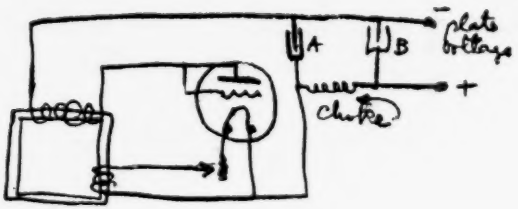
72

Mon Mar 13 1922 — Wrote on R.F. amplifier report. Made some tests with A.C. amplifier

Tues Mar 14 — Made some changes in A.C. amplifier circuit, putting in a 1 mfd condenser from RF grids to RF stabilizer arm.

Also put 1 mfd condenser from cup of crystal detector to one side of filament supply. The latter condenser seemed to aid somewhat in reducing hum.

Also made changes in rectifier circuit as shown in sketch below.



PLAINTIFF'S EXHIBIT No. 27—Continued

73

The choke and arrangement of condensers A & B (2 mfd each) seemed to give a good smoothing out effect without the use of an 8 or 10 mfd. smoothing condenser as was previously used. For the choke, a secondary coil from an Acme audio transformer was used, fitted with an iron core.

Wed Mar 15 1922 — Made more tests with A.C. amplifier. On leave in afternoon.

Thurs Mar 16 1922 — Planning assembly arrangement of rectifier unit to go with A.C. amplifier. Demonstration of laboratory apparatus to visitors.

PLAINTIFF'S EXHIBIT No. 27—Continued

74

Fri. Mar 17 1922 — Worked on design for rectifier unit. Entertained a visitor. C. P. Faling all afternoon who wanted information on receivers and amplifiers.

Sat Mar 18 1922 — Made more tests with A.C. amplifier. Conferred with Dr. Miller regarding operation of A.C. amplifier. Will get Mr. Buckley to make sharp drawings for rectifier unit.

Mow Mar 20 1922 Made more tests with A.C. amplifier. Trying to further reduce the hum. Found that circuit worked best with ground connection on filaments.

Mar 21 1922 Trying to make over an ordinary telephone receiver to be used as a loud speaking reproducer. By spacing the diaphragm a little farther from the pole pieces the receiver handled more power without distortion.

Mar. 22 1922 Found that ~~spacing~~ an increased space between diaphragm and ear caps improved reproduction also enlarging the outlet hole to about ½ inch diameter helped.

PLAINTIFF'S EXHIBIT No. 27—Continued

76

Mar 23 1922 Tried re-winding the receiver with about 400 turns of No 38 wire. Then used a step-down transformer to give proper current in telephones. This made a good loud speaker having the advantage that its windings are not directly in the plate circuit and do not receive the ~~plate~~ D.C. plate current. Of course this does not compare with the Magnavox but gives enough reproduction for ordinary purposes.

Mar 24 1922 Tried winding a magnetizing coil on the permanent magnet in the receiver to increase its magnetism by using a battery. This did not improve the volume of the reproduction due probably to the fact that

PLAINTIFF'S EXHIBIT No. 27—Continued

the diaphragm becomes magnetically saturated at a certain point. Think that a heavier diaphragm may work better.

Mar 25 1920 Heavier diaphragm not so good because of its lessened flexibility and greater inertia. Think that if Magnavox could be re-wound to operate on 300 volts rectified that a good loud speaker could be made to operate on 6 receiving tube as rectifier instead of a Tungar tube.

Tried two rectifier tubes for rectifying plate voltage. This gave somewhat better and quieter operation on A.C. amplifier.

PLAINTIFF'S EXHIBIT No. 27—Continued

78

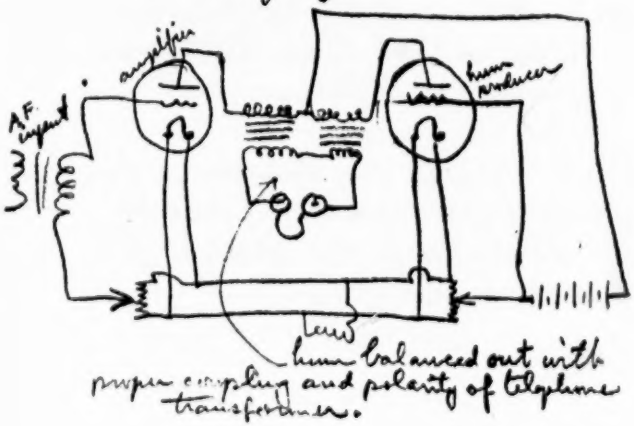
Mon Mar 27 1922 — Worked on drawings for design of ~~[illegible]~~ rectifier unit for A.C. amplifier. Will not incorporate tungar rectifier for Magnavox in this unit but will have only power transformer, rectifier tube for ~~plate~~ amplifier plate voltage, smoothing out condensers and filament rheostat.

Tues. Mar 28 — Made up temporary mounting & plate rectifier apparatus to take outfit home to try on power line there.

Wed Mar 29 — Worked on drawings for rectifier unit. Helped Dellmore on receiver for 100 meters.

Thurs Mar 30 Made some tests using a detector tube with A. C. on filament, grid being connected to stabilizer slider. Get fairly good detecting action but when audio stage is added, hum becomes to loud.

Found could balance out 120 ~ hum by using two tubes, one to amplify and other to produce hum for neutralizing:—



PLAINTIFF'S EXHIBIT No. 27—Continued

80

This circuit, however is too complicated and expensive for general use.

Thri Mar 31 — Helped Dunmore in some tests to make a ~~R~~ R.F. amplifier for 100 meters. We concluded that an air core RF transformer is most suitable at this extremely high frequency.

Sat April 1 1922 — Worked on drawings for rectifier unit. On leave in afternoon.

PLAINTIFF'S EXHIBIT No. 27—Continued

81

Mon Apr 3 1922 — Finished drawings for rectifier unit. Started its construction in shop. Cut bakelite panels and drilled holes. Made over filament rheostat. (About 4 hours in shop)

Tues Apr 4 — Worked on rectifier unit in shop. Mounted power transformer. Fitting parts. (6 hours in shop)

Wed Apr 5 — On rectifier construction in shop, assembling. (about 4 hours) Worked on R.F. amplifier report.

Thurs Apr 6 — Shop work on rectifier (about 3 hrs) Worked on R.F. amplifier report.

Fri Apr 7 — Worked on amplifier report. In shop on rectifier (abt. 2 hrs) Showed some visitors around. Talked with a Mr. Shank? on receiving apparatus.

PLAINTIFF'S EXHIBIT No. 27—Continued

82

Sat Apr 8 1922 Started carpenter on making cases for A.C. amplifier and rectifier units. Made loud speaking horn to fit into A.C. amplifier. Finished rectifier unit in shop (about 1 hour) Worked on R.F. amplifier report.

PLAINTIFF'S EXHIBIT No. 27—Continued

Mon April 10 1922 — Worked on R.F. amplifier report. Worked on rectifier unit for A.C. amplifier. Had to make some changes to enable carpenter to fit it into box.

Tues April 11 — Worked on R.F. amplifier report. Drew up design for case for A.C. amplifier.

Wed April 12 — Made some more tests with A.C. amplifier. Think a little better operation is obtained by using a negative "C" battery in the R.F. grids in place of a condenser. Have a little trouble with R.F. oscillations causing 60 ~ hum. Works best with plate voltage not over 80 or 100 volts.

PLAINTIFF'S EXHIBIT No. 27—Continued

84

Thurs Apr 13 — Worked more on A.C. amplifier. Think it advisable to put in switch to permit use of two R.F. stages when desirable. Started carpenter on case for amplifier. Making further revisions in R.F. amplifier report. On leave in afternoon.

Fri Apr 14 — Worked on revision of R.F. amplifier report. Showed visitors around lab. Helped carpenter on case for A.C. amplifier.

Sat Apr 15 1922 — Conf. with mans in textile section re. possibility of weaving a tape with strands of wire in it. To be used for flexible folding loops for A.C. amplifier unit.

Mounting variable condenser in amplifier set. On leave in A.M.

PLAINTIFF'S EXHIBIT No. 27—Continued

Mon April 17 1922 — General lab. work, showing apparatus to visitors, straightening up lab, fixed up long wave set, permanent set-up.

Tues April 18 1922 — Case for A.C. amplifier completed, fitted instrument to case. Designed wooden horn to fit in cover to case. Started carpenter making horn.

Wed April 19 — General lab. work. Demonstrations to visitors. Designing folding loop for A.C. amplifier. Will use wires sewed into cloth tape which will roll up and fit in lid of amplifier.

Thurs April 20 — On leave in morning. Fixed up loud speaking horn for A.C. amplifier to fit in lid of case. Used an old Firth decoration plume as loud-speaker. Seems to be very good.

PLAINTIFF'S EXHIBIT No. 27—Continued

86

Fri Apr 21 1922 — General lab. work cleaning up lab., showing visitors around. Conferred couple of people regarding radio frequency transformers.

Sat April 22 — Rubbed down and polished cabinet for A.C. amplifier and rectifier. General lab. work. Worked on R.F. amplifier report.

Mon Apr 24 1922 — More tests with A.C. amplifier. Trying to eliminate R.F. oscillating which causes hum. Find best results obtained with 2 R.F. stages rather than 3 stages on account of trouble with oscillations with 3 stages. Find large capacity in tuning circuit gives better operation.

PLAINTIFF'S EXHIBIT No. 27—Continued

87

Tues April 25 Think A.C. amplifier is about as good as can be made at present time. Entertained visitors. General lab. work. On leave in afternoon. Got some 2 inch tape at Goldenberg's to make loop antenna to go with A.C. amplifier.

Wed April 26 Talked with visitors who inquired regarding A.C. amplifier, especially a Mr. Franzblau from Air o Phone Co. Put amplifier in shape for test at home tonight.

Thurs April 27 1922 Amplifier worked very nicely on music from NOF. using small antenna. 1 audio stage sufficient. Picked up KDKA but his signals a little too weak to overcome

PLAINTIFF'S EXHIBIT No. 27—Continued

88

interference from A.C. hum. Conf. Mr. Diaz reg. drawings for R.F. amplifier report. Entertained visitors. On leave part of afternoon.

Fri April 28 1922

Entertained visitors and others interested in A.C. amplifier.

Experimented with R.F. transformers for A.C. amplifier trying to make 3 stages work better without H.F oscillating.

Sat. April 29

Experimented with R.F. transformers in A.C. amplifier

Entertained visitors and Mr. Ecton who wanted dope on A.C. amplifier.

PLAINTIFF'S EXHIBIT No. 27—Continued

89

Mon May 1 1922	Worked on R.F. stages of A.C. amplifier. Tried different windings on R.F. transformers. have trouble with RF oscillations causing 60 ~ hum in phones.
Tues May 2	More tests with RF stages in A.C. amplifier. Seems to be best with only 2 R.F. stages On leave in P.M.
Wed May 3	Finished construction of flexible loop to go with A.C. amplifier. Made up experimental amplifier set up for 100 meter amplification.
Thurs May 4	Started experiments for 100 meter amplifier. Will try all known methods and try to get one to work from about 80 to 150 meters

PLAINTIFF'S EXHIBIT No. 27—Continued

90

Fri May 5 1922 — Entertained visitors. Worked on amplifier for 100 meters. Indications are that an air core transformer will be best at these high frequencies. On license in P, H.

Sat May 6 — Worked on 100 meter amplifier. Making some specially wound R.F. transformer coils in "spider web" form using No. 38 wire. Entertained some visitors.

PLAINTIFF'S EXHIBIT No. 27—Continued

91

Mon May 8 1922 | Tried 100 meter R.F. transformer using two small "spider-web" coils wound with #38 enamelled wire. Used 120 turns.

outside diam. about 1½ inches.
This gave a very sharp wave length range, too sharp. About 95 to 110 meters.

Tues May 9 | Wound up R.F. transformer having iron core.

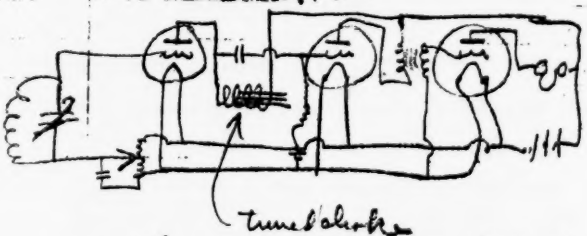
50 turns #38 enamelled on Fir and see.
This transformer unsatisfactory for 100 meters because of restricted range. Tried all different combinations of windings, coupling etc. but results not entirely satisfactory

PLAINTIFF'S EXHIBIT No. 27—Continued

92

Wed May 10 1922

Made up amplifier circuit with tuned plate coupling, using a coil wound with # 36 silk covered wire wound on a ½" square bakelite tube. 100 turns. Iron core arranged for sliding in and out to tune with circuit. —



This seems to be about best for 80 to 200 meters. Can be made to regenerate on any wave length between 80 - 200 meters by sliding iron core to proper point.

PLAINTIFF'S EXHIBIT No. 27—Continued

93

Thurs May 11 1922 Starting to make a very small variometer with #38 wire to replace choke for tuning plate circuit. Think variometer will give better operation.

Worked on fixing up buzzer line to compass house.

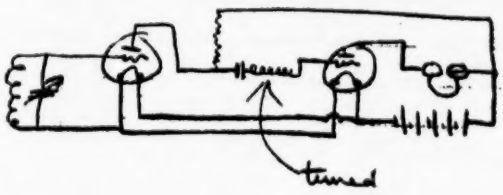
Fri May 12 Entertained some visitors. Worked on small variometer for 100 meter amplifier. Does not work as well as iron core tuned choke, latter is more controllable. Helped J. W. D. with amplifier set (1 R.F. iron core tuned plate, det. and 2 A. F) to take down to compass house for next scheduled tests with Pittsburgh.

Sat May 13 Straightened up lab. Entertained some visitors. Tried new amplifying circuit which seemed

PLAINTIFF'S EXHIBIT No. 27—Continued

94

to work pretty well.



PLAINTIFF'S EXHIBIT No. 27—Continued

95

Mon May 15 1922 — More work on 100 meter amplifier problem. Tried some resistance coupled circuits with condenser feed back from second plate to first grid. Could not make circuit oscillate below 200 meters. Tried making up a new form for single layer coil for plate circuit using tuned plate amplifier circuit. Wound 100 turns # 38 enamelled wire in single layer on a 1" tube. Then wound another layer similarly on top and saturated outer layer with collodion. Then pulled out inner layer of wire leaving outer layer a single layer self supporting coil which has extremely low capacity.

Tues May 16 — Tried this coil in a tuned plate coupled amplifier circuit. Good amplification was

PLAINTIFF'S EXHIBIT NO. 27—Continued

96

Obtained over a limited range however (about 100 to 120 meters). This indicates that the tube capacity is limiting the range. This method however seems to be very good for longer waves say from 600 to 1000 meters. This is later approaching the circuits used by Dr. Miller in his amplifier.

Wed May 17 1922

Entertained a visitor, a Mr. Paul about half the day. He wished information on the construction of receiving equipment.

Assisted Mr. Bohmer of Signal Corps Lab. in repairing an amplifier and putting it into operation.

PLAINTIFF'S EXHIBIT No. 27—Continued

97

Thurs May 18 1922

Started on writing up abstracts on A.C. amplifier and Radio Frequency amplifiers. (six abstracts to be written).

Repaired 6 stage amplifier which was used on Julius. Had been much torn to pieces, transformers disconnected, controls loose etc. As it was not especially needed in lab. Mr. Strock used it in the fog signal models to replace old 2 piece amplifier set. Better results obtained with new amplifier.

Fri May 19

Worked on long wave receiver (permanent set-up), put in new tubes, fixed up some loose connections.

Put .005 condenser across input A.F. amplifier to cut out howling. Entertained

PLAINTIFF'S EXHIBIT No. 27—Continued

98

some visitors. Helped Bohnes
& S.C. lab. on repairing
amplifier.

Sat May 20 1922 Entertained a Mr. (Van Dyck?) from G. E. Co. who desired information re. A.C. amplifier circuits. Straightened up lab. On leave in O. M.

PLAINTIFF'S EXHIBIT No. 27—Continued

99

Mon May 22 1922 — Entertained 2 parties of visitors. Helped Preston on Mfg's list. On leave 2:00 P.M.

Tues May 23 1922 — Writing abstracts for A.C. amp. papers. Fixed up A.C. amplifier for taking its picture (staining inside, cleaning + polishing) Mr. Berkeley made signs to go in picture.

Wed May 24 — Writing abstracts for A.C. amps.

Thurs May 25 — Writing + re-lettering abstracts on A.C. amplifier papers also R.F. amplifier paper

Friday May 26 — Ditto

Sat May 27 — Ditto.

PLAINTIFF'S EXHIBIT NO. 28

Monthly Report For August 1921

28

F. W. Dunmore

Work was started this month on the development of an electron tube operated relay for the service to be used in connection with the remote control of our planes. The method of operating a relay in the plate circuit of a tube when the tube is set into the oscillating condition, was adopted. A VV 202 Radiotron was used as the oscillating tube with 250 volts on the plate. This tube gave a change of 0 to 50 milliamperes when the tube went from the non oscillating state to the oscillating state. The output of a 1605-B amplifier was used to trigger off the tube. Work is still in progress to get the right coupling & voltage to give the most sensitive adjustment of the tube.

Numerous letters were written in answer to inquiries regarding the direction finder specifications.

PLAINTIFF'S EXHIBIT No. 28—Continued

Fifty cats of direction finder specifications were sent out to numerous interested parties 35 more are being prepared

A few finishing touches were put on the paper The Radio Direction Finder and Its application to navigation

Information was gotten together for the Lighthouse Bureau in order to give them an estimate of the cost of a radio beacon installation to be put on the San Francisco Lightvessel

A week or two of leave was taken this month

JWD

PLAINTIFF'S EXHIBIT NO. 29

Monthly Report For Sept 1921.

F. W. Dunmore.

The greater part of this month has been devoted to the development of a type of recorder by means of which a radio signal may be made to operate a relay. This work is in connection with project 42 for the Air Service and has to do with the remote control of an airplane by radio

This recorder in its present stage of development is constructed & functions as follows:

The output (phone terminals) of a good amplifier are connected to an audio frequency transformer (Type C-21). The secondary of this transformer is connected to the grids of two Type UV 201 Radiotrons which are operated in parallel with a 160 volt dry cell "B" battery for plate voltage. The other terminal of the transformer goes thru a 30 volt "C" battery to the filament. An ordinary telegraph relay,

PLAINTIFF'S EXHIBIT NO. 29—Continued

wound with No 38. S.S. enamel wire 12000 turns 1500 ohms, is connected in the plate circuit. A 30 volt "C" battery is sufficient to reduce the plate current to zero so that the relay remains in the open position When a signal comes in, however, the audio frequency passes thru the transformer. The - half of the cycle has no effect but the + half serves to reduce the effective voltage of the "C" battery to a less negative value. These surges of voltage changes serve to allow plate current to flow, the current being pulsating in nature but sufficiently rapid to operate & hold the relay in the closed position as long as the signal is being received. It has been found that a change of plate current from 0 to 1 milliampere is sufficient to operate the relay. Four milliamperes will operate it in any position & while being jarred badly. A strong signal will produce a change of plate current from 0 to 10 milliamperes. When using a 6 step amplifier signals from N. Y. Phila Norfolk etc serve to operate the relay very satisfactorily. It has been

PLAINTIFF'S EXHIBIT No. 29—Continued

found possible to operate the filaments of the tubes from the 110 volt A.C. line using a suitable transformer.

This type of radio relay has numerous advantages.

1. Due to the fact that the relay is of simple construction & operates with a very positive action without great delicacy of adjustment it may be used in places where vibration is excessive such as on an airplane e.g.

2. For ordinary reception the operator need not wear phones & may receive from an ordinary sounder if he is so trained.

3. Any mechanism may be controled by the relay

4. It is readily adaptable to any receiving set where sufficient amplification is to be had, as it may be plugged in the socked where the phones ordinarily go.

PLAINTIFF'S EXHIBIT No. 29—Continued

4

5 When induction noises static are not much louder than the received signal they may be completly cut out as the relay armature may be so weighted that due to its inertia the quick kicks due to static will not pull it over, whereas the signal, lasting for a period of time somewhat greater than ordinary static, will operate the relay.

A trip was also made to N. Y. this month to attend a meeting of the I.R.E. on the Kopie recorder and to inspect the radio beacon & direction finder installations at the lighthouse depot. The subject of this trip is contained in a separate report.

A laboratory report was written on, a Simple Type of Radio Direction Finder for use on Shipboard. The writing of this report was prompted by the recent sinking of the

PLAINTIFF'S EXHIBIT No. 29—Continued

5

Alaska off the Calif. coast, where th
40 or so lives which were lost might have
been saved had the rescuing ship had
even the simplest type of radio compass.
A picture for this report was taken on the
SS Northland & shows this simple form
of direction finder being worked by the operator.
The report is to be published in the Radio
Service Bulletin.

PLAINTIFF'S EXHIBIT No. 30

Monthly Report
Oct. 1921
F. W. Dunmore

Work was continued this month on the radio recorder for remote control of airplanes. It was found that a variable condenser across the secondary of the audio input transformer made possible audio tuning, which greatly increased the selectivity. Also an audio bi-path condenser was put across the relay coils which greatly increased the sensitivity, as the changes of plate current at the keying frequency were allowed to pass thru the relay coils, while the audio frequency changes passed thru the low resistance condenser bi-path. It has been possible to receive the foreign stations on this relay with two local stations of equal strength but different pitch, interfering. 3 stages of radio & 2 of audio amplification were used. A complete report describing this relay is being prepared. The experimental set-up is being properly mounted on a panel so that is portable. Measurements were made to determine the speed of operation & sensitivity of this relay. The results of these tests are included in the above mentioned report

PLAINTIFF'S EXHIBIT No. 30—Continued

An exhibit was planned for the District Lighthouse Superintendents. About 25 attended. They were guided to other parts of the Bureau where they saw things of interest to them.

The Illustration proofs for the paper, "The Radio Direction Finder & its Application to Navigation", were received and checked over & returned.

A series of curves were drawn up from data obtained experimentally on a 4 foot square coil with various number of turns from one to 240; and with various capacities across the terminals of the coil. The wavelength range covered by these measurements were from 40 meters to 36,000. meters. These curves proved quite popular and will meet the need of many inquiries regarding coil aerials & wavelength ranges.

An audibility measuring budge of the type developed by Dr. Miller was made up on a panel & was taken to N.Y. by Messrs. S.E.W. Hitchman to make measurements on the signals from the Lennox station WHB.

Many inquiries of various nature regarding the radio direction finder were answered & descriptive matter sent out.

PLAINTIFF'S EXHIBIT NO. 31

Report of Work
From
Nov 1 to Nov 15. '21.
F. W. Dunmore.

These two weeks were used in developing a method of radio telephonic communication between a U.S. Coast Guard Surf boat & the land.

Proper apparatus was gotten together, tested and packed & sent to Atlantic City N.J. where the tests were made.

A trip covering 10 days was made to Atlantic City & a radio phone set installed at the Coast guard Boat House & on a 36' Coast Guard Surfe Boat, Type H.

It was necessary to develop a coil aerial for use on the boat. This was done, the type found, was one making use of the hull as part of the coil. An Inverted L was used

Communication was maintained up to a distance of 6 miles.

A demonstration was made before the U S coast guard officials.

Complete information on this work will be found in the report. The Development & Tests of a Simple Type of coil antenna for use on the ~~Radio~~ Transmission of Radio Telephone from U S Coast Guard Surf Boats. F W Dunmore

PLAINTIFF'S EXHIBIT NO. 32

Monthly Report

Nov 15 & Dec 15 '21.

F. W. Dunmore.

Completed the radio phone tests at Atlantic City on the 15th & 16th. Packed up the apparatus & returned to Washington on the 16th.

The radio receiving relay for remote control by radio was wired up on a panel & enclosed in a case. A transformer was enclosed in the case so that the tubes may be operated from the 110 volt A.C. line. The recorder is provided with a 160 volt "B" battery also enclosed within the case so that the instrument is self contained the only steps necessary to put it into operation being to plug it on to the A.C. line & to the output of the radio receiving set. Tests were made on the completed recorder to determine its speed of operation & sensitivity. During a navy test of the Teletype (printing telegraph typewriter) the recorder was satisfactorily used to operate the Teletype by radio. Tests were also made to determine the selectivity of the recorder by using audio tuning in the 2 stages of amplification used with the recorder.

PLAINTIFF'S EXHIBIT No. 32—Continued

A report on the radio phone tests at Atlantic City was written. Prints were obtained & mounted to accompany the report to show the radio phone set as installed on the Coast Guard Surf boat.

The permanent set-ups in room 203 were put in working order so that visitors may be shown the direction finder & radio phone in operation.

Experiments were made to determine the possibility of using the 110 AC supply to replace the 160 volt "B" battery used in the recorder. It was found that by using one receiving tube as a rectifier & a 4 microfarad condenser & 7 henry coil to smooth out the rectified DC, that 160 volts DC could be obtained which could be used to replace the "B" battery. This improvement makes possible the operation of the recorder from the 110 volt AC line, as both filament & plate current are now obtained from that source. The elimination of storage cells to operate the filaments & dry cells of high voltage for the plate are steps which make the recorder a practical & useful device.

PLAINTIFF'S EXHIBIT No. 32—Continued

Experiments were also made to find a means of operating the tubes of a receiving set from the 110 Volt AC supply. Only partial success was attained

The galley proof on the paper The Radio Direction Finder and its application to Navigation was finally received & gone over & returned

These radio phone tests were conducted with the Post Office Dept in connection with the new radio phone installation at the Post Office Bldg.

Respectfully submitted

F W Dunmore

PLAINTIFF'S EXHIBIT NO. 33

Monthly Report - Dec 15 to Jan 15, (21022)

F. W. Dunmore.

Development work on the new type B recorder was completed this month. It was found that the recorder could be successfully operated from the 110 A.C. 60 ~ line, the filament current, plate & grid voltages being successfully obtained from this source. Material was collected & drawings made for a cabinet & panel to contain a type B recorder. A circuit diagram for the above recorder was drawn up & the report modified to include the new type recorder. A copy of the report was sent to the Journal of the A I E E. for publication.

A tape register was received this month & connected up to the type A recorder. Tests were made to determine its speed of operation. It was found that 45 words per minute was the limit of this particular Bunnell register. It is the ink tape type. Tape record of Radio Central at ~~of~~ Long Island was successfully made at 45 words per minute. Good tape record was also gotten on POZ, Germany. A Western polarized high speed relay was tried out with the recorder to replace the ordinary relay now used. This relay was not as well adapted to the recorder circuit as the old one.

PLAINTIFF'S EXHIBIT No. 33—Continued

As usual numerous visitors were shown about the laboratory.

The proof reading on the Direction Finder paper was completed this month & the page proof returned to the Printing Office.

A method of selective control by radio was thought out in connection with Air Service Project # 2. Briefly it is as follows:- Three or more transmitting sets (undamped) are operated simultaneously by a common key, each transmitting on a different wave-length. Three or more receivers are each tuned to one of the transmitting wavelength, each receiver operating a recorder (Type A or B). A heterodyne for each receiver is adjusted to give the desired audio frequency for each particular recorder. The recorder relay contacts are connected in series so all must close at once to operate the relay which controls the desired mechanism. Should an interfering station operate one relay the control mechanism does not operate.

The best transformer design for supplying the filament voltage, grid & plate voltages was worked out & a transformer made up. Data on this transformer was carefully recorded so that it may be duplicated.

Numerous letters were answered.

PLAINTIFF'S EXHIBIT NO. 34

Monthly Report

Jan 15 to Feb 15 1922.

F. W. Dunmore

The first type "B" relay recorder was completed this month. A Bunnell and Mahrum relay were tried out with this recorder. Altho the Mahrum relay may be operated at higher speed the Bunnell relay was somewhat easier to adjust & so was used The coils were rewound with a total of 22,000 turns of no 38 wire. With 3 or 4 milliamperes in these windings a very positive pull is obtained on the armature Tests on the completed relay recorder showed it to operate entirely satisfactorily with the AC current as the only source of power.

By the use of the audio tuning feature on the Type A & B recorders several interesting tests were made. NSS was tuned in, & the two recorders inputs put in series & connected to the output of the audio amplifier. One recorder was adjusted to operate on the note of the sending wave and the other adjusted to operate on the spacer wave. Simultaneous tape record was then made, one of the spacer wave, the other the sending wave. By adjusting the tuning to a point where two stations could be heard sending at the same time (the pitches being different), two messages were recorded at the same time from two of the high

PLAINTIFF'S EXHIBIT NO. 34—Continued

power stations on this side.

As a result of these tests the possibilities of di and triplex transmission on one wavelength were realized The method consists of modulating the output of a continuous wave generator, at two or more audio frequencies. The transmitting keys are in the audio modulating circuit. Different types of modulators were tried, choppers, buzzers & tube generators oscillating at audio frequencies The latter proved most satisfactory. Thus far two messages have been transmitted on the same wavelength over very short distances. These messages were received, one on one recorder, the other on the other recorder both recorders being on the same antenna.

At the request of the navy Dept, Dr Miller made tests on the type A & B recorder & submitted a report on same.

Tests were made on the best method of modulating a source of continuous wave with two or more audio notes and keeping both notes pure. Two modulator tubes were tried but did not work on the circuit used Care note & to harmonic on a single modulator tube worked

A few radio phone tests were made for the P O Dept

Some work was done with Mr Lovell on the development of a radio-audio amplifier operated entirely from the A C supply.

Numerous meetings were attended.

A plan of procedure on short wave transmission for the Air Service was worked out & a national gotten together to start it

F W Dunmore

PLAINTIFF'S EXHIBIT NO. 35

Monthly Report Feb 15 to Mch 15 1922

J. W. Dunmore.

A radio receiving set was installed for the Director in his apartment

The type A recorder was overhauled & new 'B' & 'C batteries put in same. Tests with the type A & B "B" recorders connected in series each working a tape register showed that it was possible to make a record of the space wave & sending wave of NSS. simultaneously.

Another application of the recorder was worked out on paper, whereby a radio compass may be made to be self setting. Briefly it is as follows. The radio compass is of the crossed coil type with a switch for first throwing one receiver & recorder on one coil, then another receiver & recorder on to the other coil. The relay coils of each recorder all work on a common armature but in opposite sense. If the coils are set on the equi-signal position the armature vibrates rapidly between the two sets of coils & does not make contact on either contact long enough to close a circuit. However if one the coils are off the equi-signal position the armature will hold over against one contact as a greater current will be in that set of coils

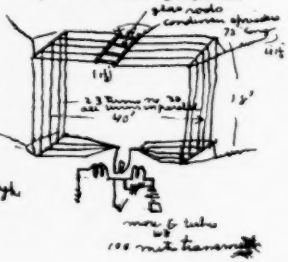
PLAINTIFF'S EXHIBIT NO. 35—Continued

Still another application of the recorders was worked out for remote control by radio. It is as follows - Continuous waves of slightly different wave lengths are sent continuously from two equi-signal crossed coil transmitters. Heterodyne is done on a single antenna two beat notes being received. Two recorders are connected in series to the receiver each being tuned to one of the heterodyne notes. The two recorders have a common relay armature. When the receiver (object to be controlled) is on the equi-signal line the armature does not move as there are two equal & opposite pulls. However if the receiver gets off this line one note is stronger than the other & the relay operates to one side thus controlling mechanism to bring the receiver back on the equi-signal line.

Wrote up a report on The Relative Advantages and Disadvantages of Locating the Radio Direction Finder on Shore & on Shipboard.

Worked out a 100 meter tube transmitter in connection with project E-26 for the Air Service

The above loop was made up as shown & numerous tube circuits tried out to find the best for 100 meter work. It was found that the one shown gave the best results it being possible to get 3 amps in the loop with one W.E. 5th "G" tube. Further tests will



PLAINTIFF'S EXHIBIT No. 35—Continued

be made with 3 or 4 tubes in parallel & other antenna design.

400 dollars was set aside by the navy for the construction of two type B recorders. Work was started for the Signal Corps building parts of two type B recorders which they have ordered. The type A recorder was loaned to navy Dept for comparison test with the B rec relay.

Made out list of radio apparatus needed for different lines of work in Rad Labs sent for in same

Proof read recorder paper which is to come out in the April issue of the A.I.E.E.

Numerous inquiries were answered regarding coil aerials, recorders & R.F. amplification.

Several suggestions were given to Sowell on the development of the A.C. amplifier & his report on same was read.

A trip was made to N.Y. & a check calibration made of the D.F. on the Light House Tender Tulip. no variations greater than three degrees were found. I had a long talk with Mr Yates regarding radio compass & beacon developments and it seems the commercial companies do not take the interest they should in developing & installing direction finder sets.

Attended the radio convention in the Penn Hotel. Found a good deal of second class apparatus in exhibition

F W Wunmore

PLAINTIFF'S EXHIBIT NO. 36

Monthly Report
Mch 15 to Apl 15, '22.
F W Dunmore

In connection with the Air Service short wave project a type "G" Western Electric Tube circuit was worked out to give the best results with the type of coil aerial used for the 100 meter work. After working some time with various couplings a satisfactory one was found which gave the greatest current in the loop - 3 amperes I.C.W. at 110 meters. A chopper was used in the filament connecting lead to the oscillating circuit to give the I.C.W. A test was made at 5 miles distant from the Bureau using a 3 turn 4 ft loop & two stages of audio. A just readable signal was obtained at this distance. The detector tube was not used in the oscillating state. Further transmission tests with Pittsburgh are being arranged.

A short wave (100 to 125) meter 2 stage radio, 2 stage audio amplifier was developed for conducting tests with the 100 meter transmitter. The amplifier could be made to oscillate over the

PLAINFIFF'S EXHIBIT No. 36—Continued

range. A single wire 50 ft antenna was put up for receiving from Pittsburg S.H.K, with this amplifier & variometer & suitable receiving circuits connected up. A test schedule was arranged with S.H.K.

Mr Bedford, detailed here for 3 days from the Lighthouse Depot at Tompkinsville was instructed in the use of the direction finder. He is to take over that work at Tompkinsville A balancing transformer was made up for the new direction finder installation to be made on the Lighthouse Tender Larkspur.

Proof read the final edition of S.P. 428.

Got material together for calibrating the Direction finder on the U.S. Transport Cambrai I went over the specifications for the present installation. Went to New York & went out on the Cambrai & made a calibration of the D.F on the Cambrai. The results of this work are covered in a separate report.

A good deal of desk work was required this month answering the many inquiries which are now coming in.

Took the A.C. amplifier home & made tests with it both on the loop & using the power line as antenna. Dr Dellinger also made the power line tests with me. Signals weak on power line

PLAINTIFF'S EXHIBIT No. 36—Continued

A couple of the permanent set-ups were just in working order.
Consulted with Tupper re use of beacons on buoys
Wrote a report of the ~~Cotsen~~ calibration made of the D.F. on the U S T ranger Cambria
Got material together and sent to my yatch at Tompkinsville to conduct the life boat direction finder tests I advised him to undertake
This consists in finding the location of a small life boat by means of a direction finder and low power beacon signals being sent from the life boat.

Working drawings of the type "B" relay recorder were started

Wave length and width measurements were made on Cape May (WCT). Mr Bass's method of audibility measurement was developed mechanically into a possible method of measuring distruments of a transmitting station at a distant receiving station. This is an equi-signal method which gives ratios of audibilities at different wavelengths.

The final design of A.C. amplifier was decided upon, after talking over the question with Mr Sowell The amplifier is to contain a horn & collapsable loop on the cover with a loop tuning condenser in body

F W Dunmore

PLAINTIFF'S EXHIBIT No. 37

Monthly Report
April 15 to May 15. '22.
F. W. D unmore

37

Some time was spent this month in getting a detail drawing of the recorder drawn up. Assistance was also given to the Signal Corps in getting two recorders built up for their use.

A trip was made to Chicago to present a paper on A Relay Recorder For Remote Control by Radio at the convention of the A I E E.

Considerable work was done this month on the 100 meter coil aerial transmitting set. Three more 50 watt tubes were added making a total of 4. About 5½ amperes were obtained in the coil aerial with these four tubes operating in parallel The wave length was checked and found to be 108 meters. The high voltage motor generator set was moved down in the shack with the rest of the equipment. A Sat. evening schedule was arranged with Mr Conrad of the Westinghouse Electric & Mfg Co of Pittsburgh and three tests made. Each of the tests were very successfull, the signals being not only heard in Pittsburgh but in Boston also. The signal strength in

PLAINTIFF'S EXHIBIT No. 37—Continued

Pittsburgh was about 1000 audibility on a a-25 detuned and one stage of audio amplification. The ICW was also heard but not as loud. The was practically no fading. The tests were made in the evening between 10 & 11 PM.

Some further work was done on a 135 meter receiving set. It was found that a single turn coil aerial about 20 ft square was best for reception at this wave length. Using this coil & a detector & 2 stages of audio amplification with a plate feed back circuit very good signals were obtained from Pitts & a station in Boston working on approximately 140 meters. Radio phone from the 135 meter set was also heard with this combination.

Material was written & collected for a conference on Direction Finders called by Dr Stratton. This conference was attended & the direction finder situation discussed by the representatives who came from the different companies interested in the manufacture of direction finders. The Federal Wireless Telegraph Co & the Wireless Specialty Apparatus Co seemed to be the only ones ready to put this device into production

PLAINTIFF'S EXHIBIT NO. 38

Monthly Report May 15 to June 15 '22.
F.W.D unmore

38

Some very interesting results have been obtained this month in short wave transmission. Daylight and darkness tests have been made with 8XK (Frank Conrad E Pittsburgh Pa.) Two tests were made extending from 12 noon to 10.30 at night in order to determine whether there was any difference between the received signal strength at night and in the daytime. As a result of these two tests it would seem that day-light transmission at 105 metres is about as good as during darkness. Some fading was noted but nothing like that experienced on 200 metres. The special spreader condenser antenna of the coil aerial type was used for transmission during these times. Signal audibilities of 300 were reported in Pittsburgh in broad day light, reception being done on a detector and 1 stage of audio. Four 50 watt tubes were used for transmitting about 5 amps at 105 metres being obtained in the coil antenna. A directional transmission test was made by sending with the spreader condenser first in the center of the top section of the loop & then in the center of the south

PLAINTIFF'S EXHIBIT NO. 38—Continued

down load. An audibility of 2000 was reported on the second arrangement. The other was sent at a wrong time & the operator was not listening. These tests were made in the daytime. It is not known yet whether this audibility was with 1 or 2 stages of audio. Further tests of this nature are to be conducted.

Two type B radio receiving relays were furnished for the Signal Corps & tested out this month. They both worked entirely satisfactorily. Tape record was obtained on 7th. Wood N.J. with a detector & 2 stages of audio used with the recorder. Also with a good strong signal it was found possible to operate the relay on an a note below audibility. The relay was demonstrated to officials of the Signal Corps & tests are to made under their actual working conditions.

The set of detailed working drawings on the relay has been about completed this month. Some time was devoted to details connected with this work.

A report was practically completed on the C method of Continuous Wave Transmission and the Results Obtained.

A short wave 80-150 metre receiver was designed & parts obtained for making up some

=WD

PLAINTIFF'S EXHIBIT NO. 39

Report for November 15 to Dec 15, 1921

P. D. Laurel

Much time was spent with Mr. Bohnen of the Signal Corps Laboratory in writing a complete report on work done on the tractor radio compass problem and a copy will be submitted to the Bureau as soon as typed.

Some work was done on the high frequency bridge set but to date the problem has not been satisfactorily solved.

In connection with the tractor compass work, a few more field tests were made to test its accuracy, with very good results and the report will cover the entire problem from the earliest tests to the final ones.

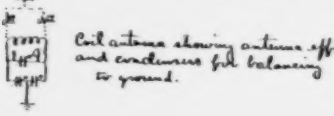
PLAINTIFF'S EXHIBIT NO. 40

(1)

December 15, 1921 — Jan. 15, 1922

The portable time signal set was repaired and put in good condition for exhibition purposes.

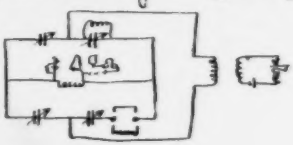
Work on the H.F. bridge was taken up. It was planned to apply the principle of balancing out the antenna effect in a coil antenna by means of condensers, to the bridge, in the manner shown in the two figures below.



A buzzer circuit (Kolster Decremeter) was used as source of signal and coupled into the input of the bridge with an ordinary coil across the input. A coil and condenser in shunt with an electron tube detector was connected across the output, telephones being connected in the plate circuit of the detector.

This circuit gave a very sharp and silent balance when the ratio arms are adjusted. The coupling between the bridge input and source of e.m.f. must be adjusted for best balancing.

An unknown coil was connected across one of the condenser arms and a 50 ohm H.F. resistance connected alternately in and out of circuit in series with condenser in opposite arm and the applied e.m.f. tuned to various frequencies to determine the behavior of the balancing at different frequencies, see circuit below.

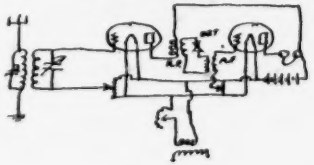


PLAINTIFF'S EXHIBIT NO. 40—Continued

It was found that the balancing was practically destroyed when the input e.m.f. frequency approached that of the unknown coil and condenser, while the 50 ohm resistance was in circuit but with resistance shunt circuited the balance was maintained.

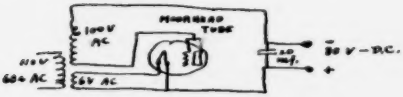
Some experimental work has been done to determine the feasability of using the 60 cycle 110 volt lighting current as a source of filament and plate voltages in an electron tube receiver both in radio frequency and audio frequency amplification and detectors.

Various amplifin circuits were tried and it was found that probably the best combination was when radio frequency alone was amplified and a crystal detector used as rectifier. The latter, however is very objectionable in such a circuit because of its instability and further tests will be conducted to utilize a tube detector if possible. The hum due to the A.C. on the filaments was reduced to a minimum by employing voltage dividers on the grids so as to keep the grids always at zero potential. Some hum however is still present in spite of this, due to the changing filament temperature which affects the grid voltage. Several means were tried to balance out this residual hum but with little success. A crystal detector gave much better operation than a tube detector but its use is very ~~impracticable~~ impractical. The best circuit is shown below.



PLAINTIFF'S EXHIBIT NO. 40—Continued

The use of A.C. on the plates was next tried, with D.C. on the filaments. A 1 tube rectifier was used to rectify the 80 volts from the transformer and a 20 microfarad condenser used to smooth out the voltage. This worked very nicely and gave very quiet operation, as good as high voltage batteries for all ordinary purposes. The rectifying circuit is here shown.



Further tests will be made in an effort to entirely eliminate the hum due to the A.C. on the filaments also to use a tube detector in place of the crystal and to use A.C. on the filaments and plates simultaneously.

Respectfully submitted,

P. D. Lowell.

PLAINTIFF'S EXHIBIT NO. 41

(5)

Monthly Report for Jan. 15 - Feb. 15, 1922

Work was continued on the problem of using the 110 volt A.C. power for the filaments and plates of an electron tube amplifier. It was found that the amplification could be considerably increased by introducing condensers of .02 microfarads capacity in the grid circuits of the amplifier tubes. These condensers, however were later replaced by a battery which impressed about 10 volts negative charge on the grids This gave maximum amplification with a minimum of hum.

The possibility of using a tube detector was practically given up because of the large amount of hum present when it is used. A good galena crystal detector gave practically as good rectification and helped to reduce the hum immensely.

The use of A.C. rectified by a Tungar, on the filaments was tried and abandoned because of the distortion of the wave form during rectification, which made it impossible to balance out the hum in the grid circuits.

Rectified A.C. on the plates worked very nicely, an ordinary amplifier tube being used to rectify 300 volts A.C. This was smoothed out by a 20 microfarad condenser. The D.C. output from the rectifier tube could be varied from 10 volts to 300 volts by adjustment of it's filament temperature.

It was found that a one to one ratio telephone transformer helped to reduce the hum in the receivers.

PLAINTIFF'S EXHIBIT No. 41—Continued

(2)

a Magnavox loud speaking telephone was also introduced into the circuit and it was found that its field coil could be operated on the A.C. power by use of a Tungar rectifier which gave 6 volts D.C. across the coil. The high impedance of the field coil served to smooth out the rectified A.C. An additional choke in series helped to reduce the hum in the loud speaker.

The final circuit as developed, consists of 3 stages of radio frequency amplification, crystal detector, two stages of audio frequency amplification together with the Magnavox, if desired and the power transformer and the rectifier circuit.

Shop drawings have been made for two units, the 5 stage amplifier unit and the rectifier unit. Investigation seems to show however that the possibility of having these constructed in the shop is very remote.

Respectfully submitted

P. D. Lowell

PLAINTIFF'S EXHIBIT NO. 42

Monthly Report

Feb. 15 to Mar. 15, 1922

Preliminary experimental work on the A.C. amplifier was completed and the construction of a finished amplifier started in the shop. This set was completed and after some further experimenting was made to operate very satisfactorily. The rectifier unit to go with the amplifier unit has not been constructed yet.

The operation of the whole set was improved somewhat by the addition of a condenser here and there to help reduce the hum.

A complete report on this subject has been completed and all details are incorporated therein.

A report has also been written on the subject of radio frequency amplifiers.

PLAINTIFF'S EXHIBIT NO. 43

Monthly report for March 15 to April 15, 1922.

The construction of the amplifier unit which operates on the 60 cycle power circuit has been completed with the exception of a collapsible loop antenna and a tuning condenser. The rectifier unit has also been completed. The loop antenna will consist of several strands of wire sewed into a cloth band, which can be rolled up and stowed in the cover to the amplifier.

A report on radio frequency amplifier experiments has been written and is in the process of revision.

PLAINTIFF'S EXHIBIT NO. 44

April 15 to May 15, 1922.

P. D. Lowell.

Experimental work on the amplifier operated from the 110 volt 60 cycle power has been suspended and a complete portable set made up in the shop. This set consists of two units, the amplifier and the rectifier. The amplifier has been fitted with a loud speaking telephone and a folding loop antenna which is about 10 feet on a side when opened out.

A report on this A.C. operated set has been made and submitted for publication. It will probably appear in the July issue of A.I.E.E.

A report has also been completed on the subject of Radio frequency amplifications by means of electron tubes.

Some work was done on the problem of R.F. amplification at 100 meters. Present tests indicate that a circuit using tuned plate coupling is most satisfactory. The tuning of the plate circuit is accomplished by means of a sliding iron core which varies the natural period of an inductance in the plate circuit.

PLAINTIFF'S EXHIBIT NO. 45

Monthly Report

May 15th to June 15th, 1922

P. D. Lowell.

The writing of the paper on high frequency amplifiers and one on the development of the amplifier using A.C. supply has been completed as well as the six abstracts which go with them.

A 100 to 150 meter regenerative receiving circuit has been developed for Mr. Dunmore in connection with his 100 meter transmission problem. This will be made up in the shop into a complete compact set.

Started work under Mr. Preston on construction of audio frequency amplifier for publication in Bureau circular. Two sets of one stage each have been completed experimentally and are now in the process of being permanently finished. The written description on the construction of them is also in progress.

PLAINTIFF'S EXHIBIT NO. 46

Monthly Report for June 15 to July 15, 1922
P. D. Lowell.

Two sets of audio-frequency amplifiers were assembled, wired and tested for Mr. Preston. Also wrote up instructions for operating same.

A radio time signal receiver and relay has been constructed and tested out for the clock section of the Bureau. This set contains a single circuit tuner with coil and shunt variable condenser, detector tube and two audio frequency stages of amplification. A high resistance relay is connected in the plate circuit of the last audio amplifier tube. It was found that sufficient signal was obtained from Arlington's spark set to operate the relay without using negative grid potential on the grid of the last tube. The set is small, rugged and simple as it has only two adjustments, one for tuning the antenna and one for controlling the brilliancy of the filaments.

PLAINTIFF'S EXHIBIT NO. 47

EDITORIAL RECORD

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TITLE OF PAPER

A Relay Recorder for Remote Control by Radio.

BY AUTHOR TITLE OF AUTHOR

F. B. Dunmore, Associate Physicist.

SHORT TITLE (less than 36 letters) for running heads Relay Recorder

ABSTRACT (125 words or less, for Cir. 24) This report describes a type of radio receiving relay which is designed to be operated from the output of an ordinary receiving set. It consists in the use of a receiving tube with 160 volts on the plate and with a relay inserted in the plate circuit. The grid voltage of the receiving tube is adjusted to a value which reduces the plate current to 0. With an incoming signal this grid voltage is changed, thus allowing a current of to flow through the relay coil in the plate circuit. This recorder may also be operated from the 110 volt a.-c. supply circuit entirely independent of any batteries.

Signature of Author F. B. Dunmore Title of Author .....

READERS for Div. Editorial Committee

READERS for Bureau Editorial Committee COMMENTS

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EDITORIAL COMMITTEE

Recommend publication

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APPROVED FOR PUBLICATION

author S. W. Stratton, Director

MS. Sent to Department for Printing Dec 30 1921

Work Received .....

PLAINTIFF'S EXHIBIT No. 48

Vol. XLI. April, 1922. No. 4. Journal of the American Institute of Electrical Engineers. Published by the Institute. 33 West 39th St., New York City.

A RELAY RECORDER FOR REMOTE CONTROL BY RADIO

By F. W. Dunmore, Radio Laboratory, Bureau of Standards

Review of the subject.—Relays have been used for many years in wire telegraphy and other electrical work. The practical operation of relays actuated by received radio signals is a comparatively recent development, and has been made possible by the development of the electron tube amplifier.

This paper describes the development and the operating principles of a type of relay recorder which is designed to operate from the output terminals of a radio receiving set and which may also be operated by any other source of audio-frequency signal.

By the use of special electron tube circuits the audio-frequency signal is caused to operate an ordinary telegraph relay.

In order to avoid the necessity for using a very sensitive relay, designed to operate on currents of a milliampere or less, which would have delicate adjustments and light contacts and spring tension, advantage was taken of an electron tube amplifier, which has now become a reliable radio instrument, to increase the input voltage to the relay circuit thus making possible the use of a simple ordinary high-resistance telegraph relay. The relay device has therefore been developed to operate from the output circuit of any suitable amplifier in place of the ordinary telephone receivers.

The operation of the relay may serve to work a sounder, buzzer, tape register or any mechanism for remote control by radio.

Two types are described. One type is designed to be operated from batteries. The other type is designed to operate entirely from any 60-cycle 110-volt lighting circuit and this feature makes this type simple and inexpensive to operate, durable and practical. Another unique feature is described which is that of tuning to different audio-frequencies whereby any one of three signals, each of a different audio pitch, may be caused to operate the relay to the exclusion of the others.

Curves and diagrams are shown illustrating the principles of operation.

By the use of two of these relay recorders connected in series across the output terminals of a single radio receiving set, two messages sent on practically the same wave length but of different audio-frequencies, have been accurately received simultaneously.

PLAINTIFF'S EXHIBIT No. 48—Continued

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TYPE A—FOR USE WITH BATTERIES

1. Object of development.—The object of this investigation was to develop a relay which should operate by received radio signals.

2. Requirements.—To be satisfactory as a relay recorder the device should have the following characteristics: (1) it must be of simple construction with few adjustments; (2) it must be easy to adjust and capable of being put into operation quickly; (3) it must be selective and as free from static and such disturbances as possible; (4) it must be capable of operating at a speed of at least 12 times per second; (5) it must respond to weak signals; (6) it must be of strong design, durable and capable of maintaining its adjustments; (7) it must be portable.

3. Circuit used.—In order to avoid the use of a very sensitive relay designed to operate on currents of a milliampere or less, with delicate adjustments and light contacts and spring tension, advantage was taken of the radio-audio amplifier (which has now become a reliable radio instrument) to increase the input voltage to the relay circuit, thus making possible the use of a simple ordinary high-resistance telegraph relay. The relay device has therefore been developed to operate from the output circuit of any suitable amplifier in place of the ordinary telephone receivers. The only adjustment necessary is that of an ordinary telegraph relay.

Fig. 1 shows the wiring diagram. *A* is a telephone plug for connecting the relay device to the amplifier output. *B* is a phone socket, so that if desired the operator may listen to the received signal in the ordinary way. *C* is an audio transformer of the type used in audio amplifiers, the type used at present being a Signal Corps Type C-21. *E* is a two-megohm, grid leak. *Q* is a 0.0006-

To be presented at the Spring Convention of the A. I. E. E., Chicago, Ill., April 19–21, 1922.

PLAINTIFF'S EXHIBIT NO. 48—Continued

microfarad variable condenser or 0.0003-microfarad fixed condenser. *D* is a 60-volt variable "C" battery variable in steps of approximately three volts. *J* is a 160-volt dry "B" battery self-contained within the set. *K* is a type UV-201 Radiotron. *F* and *H* are each a one-microfarad paper condenser. *T* is an ordinary telegraph relay rewound with 12,000 turns of number 38 S. S. C. enamel wire. *A'* is the output to be connected to the apparatus to be controlled. *L* is a step-down transformer for operating the tube filaments from the 110-volt a-c. supply when such a supply is available.

4. Principle of operation.—The principle of operation is illustrated in Fig. 2. By means of the variable "C" battery *D*, the grid voltage is adjusted to approximately 30 volts at which value the plate current is zero, as shown at *A*. The incoming audio-frequency voltage impressed on the grid varies the grid potential, for example, from—30 to—20 volts. The 10 volts decrease from—30 to—20 causes an increase, for example, from 0 to 10 milliamperes, while the increase from—30 to—40 volts is not effective in causing a plate current to flow due to the fact that—30 volts is already sufficient to reduce the plate current to zero. The result will be a pulsating direct current of 10 milliamperes, maximum amplitude, in the plate circuit. This current, flowing through the plate circuit and condenser *F* causes an increase in the plate current at the keying frequency, which change, passing through the relay coil will pull the relay armature over, making contact at *T*, which contact may control any mechanism desired. With the "C" battery grid voltage adjusted for maximum sensitivity it was found that static induction, etc., operated the relay. When these disturbances are not as strong as the signal their effect on the relay may be overcome as shown in Fig. 3. For example, the "C" battery is shown increased to—35 volts, the critical value for maximum sensitivity being—30 volts. The disturbances due to stray currents, etc., merely reduce the "C" battery voltage to—30 which is not sufficient to cause plate current to flow. However, the signal, being of greater intensity than the stray currents, reduces the voltage to—25 which causes a plate current of five milliamperes. It will be seen therefore that all disturbing effects, if of less intensity than the signal, do not affect the relay.

5. Method of increasing sensitivity and selectivity.—During the development of this relay it was found that the rectified audio-frequency current in the plate circuit caused the relay armature to chatter rapidly and make a poor contact with the fixed contact point through which the circuit is closed. This was overcome completely, however, by the addition of a one-microfarad condenser across the relay coils. This served the purpose of an audio-frequency by-path

FIGURE 1.—Circuit diagram of relay for use with batteries

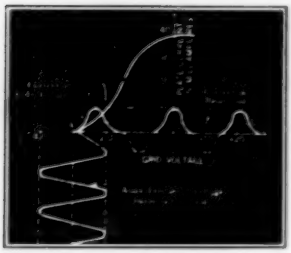

FIGURE 2.—Tube characteristic showing principle of operation of relay recorder

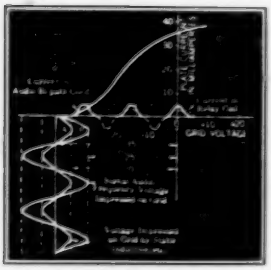

FIGURE 3.—Method of eliminating static and induction noises which are not stronger than signal

PLAINTIFF'S EXHIBIT No. 48—Continued

for the highly inductive winding of the relay, thus greatly decreasing the resistance of the circuit. The change of plate current due to this audio-frequency caused a second change which occurred at the keying frequency. This latter change passes readily through the relay coils and exerts a strong steady pull on the relay armature without the least chattering.

It was also found that the 0.0006-microfarad variable condenser, Fig. 1, across the secondary of the input audio transformer made possible audio tuning, which increased the selectivity considerable. This tuning was very sharp and it was found that European stations could be made to operate the relay while a high-power station here in the United States would fail to operate it, although the high-power station was coming in on the same wave length and slightly stronger. This was made possible by adjusting the heterodyne note of the European station to a frequency different from that of the local station and then tuning the secondary of the audio transformer to that frequency. The 0.0006-microfarad variable condenser may be replaced by a 0.0003-microfarad fixed condenser and the audio tuning accomplished by adjusting the heterodyne note to the resonant frequency. By means of this audio tuning one of three stations transmitting simultaneously has been selected and caused to operate the relay although all were of equal intensity.

By the use of two relay recorders connected in series across the output terminals of a single radio receiving set, two messages sent on practically the same wave length but of different audio frequencies have been accurately received simultaneously.

6. Speed of operation.—Tests showed that with a signal strength sufficient to produce a plate current of 10 milliamperes the relay could be operated at a speed of 48 contacts per second, the contact being sufficient to operate a buzzer. With three milliamperes in the plate circuit a speed of 27 contacts per second was obtained. With one milliampere a speed of 19 per second. In each case the relay armature spring tension was adjusted for the best operation.

7. Sensitivity.—As stated above, this relay was designed primarily with the intention of obtaining a device which should be durable, simple in operation, and strong in construction. Sensitivity is obtained by means of radio-audio amplification, thereby increasing the voltage input to the relay circuit and eliminating the necessity of extreme sensitivity in the relay. Tests at 600 cycles showed that the relay circuit was fairly sensitive, as approximately 1.3 volts at the input terminals of the audio transformer in the relay circuit caused a current of five milliamperes to flow through the relay coil in the plate circuit.

PLAINTIFF'S EXHIBIT NO. 48—Continued

8. Durability.—As the relay instrument used in this recorder is of the ordinary telegraph type, its durability is well established. The only elements requiring occasional renewal are the two electron tubes, the 60-volt "C" battery, and the 160-volt "B" battery.

9. Portability.—The complete recorder, with the exception of the filament lighting battery, is contained in a cabinet 7 in. by 13 in. by 11 in., as shown in Fig. 4.

10. Uses.—1. As an ordinary receiver it has advantages over reception with telephone receivers, for one may receive by buzzer or sounder with all induction and interfering noises eliminated (if not louder than the signal).

2. A tape or drum-type recorder may be used and a copy made without a trained radio operator.

3. Time signals may be recorded.

4. A call system may be worked by a time switch connected to close the filament circuit for a given time at set calling intervals.

5. Any form of mechanism may be operated by an incoming signal.

6. A receiving station may be located remotely from the transmitting station and the radio signals relayed by wire to the operating room some miles distant.

In conclusion it may be stated that a relay of this type should operate satisfactorily, without attention, on an airplane where mechanical vibration may be excessive as the pull on the armature with three milliamperes, or over, in the relay coil makes possible the use of a spring tension on the relay armature sufficient to keep it from moving due to mechanical vibration of the relay.

It would seem that the above-mentioned feature makes this remote control relay more serviceable than those now on the market which require delicate adjustment of spring tension, contact points, and suspended vibrating elements.

TYPE B—FOR USE ON THE 60-CYCLE, 110-VOLT, A. C. SUPPLY

This recorder is similar in construction and operation to the Type A recorder, except that the plate and grid voltage (B and C battery) are supplied from the 60-cycle, 110-volt, A. C. supply. The current for operating the tube filaments is also obtained from this source, so that the recorder is operated entirely independent of any form of batteries. It is only necessary, therefore, to connect to the 110-volt, A. C. line and the recorder is ready to operate.

The method of operating the recorder from the A. C. supply consists in the use of the two receiving tubes as rectifiers as shown in

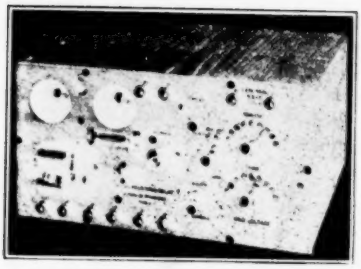

FIGURE 4.—Type A relay recorder for use with batteries

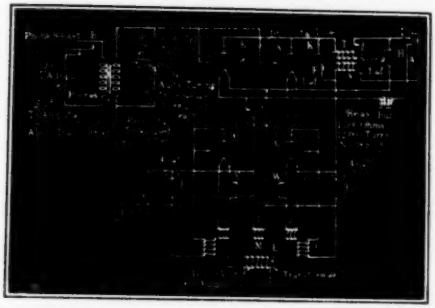

FIGURE 5.—Circuit diagram of relay recorder for use on the 110-volt A. C. supply

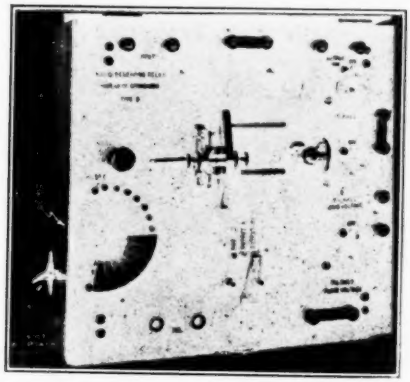

FIGURE 6.—Type B relay recorder for use on the 110-volt A. C. supply

PLAINTIFF'S EXHIBIT NO. 48—Continued

Fig. 5. The tubes *Y* and *Z* are used as half wave rectifiers, one supplying the plate voltage, and the other the grid voltage. When used as rectifiers, receiving tubes should have the grids and plates electrically connected together. A special transformer *M* with six windings is used. Two of the windings *G* and *J*, supply the filaments of the two rectifier tubes. A third, *I*, the filaments of the recorder tubes. A fourth, *U*, the high voltage for the plate. The fifth, *L*, supplies the grid voltage, and the sixth, *E*, is the 110-volt primary winding. The rectified alternating current is smoothed out by means of four microfarad condensers *P* and *R*, connected across the output terminals. As the currents in the grid and plate circuits are small, smoothing out inductance was found unnecessary. It was found necessary to put 40,000 ohms, as shown at *O*, across the output circuit of the rectifier tube supplying the voltage to the grid, as the grid is otherwise insulated from the filament of tubes *K* by the rectifier tube. By means of the filament rheostats, *X* and *W*, the grid and plate voltages may be varied over any ranges desirable for the most efficient operation of the recorder. By the use of binding posts with straps, as shown in Fig. 6, the type B recorder may be operated from *A*, *B*, and *C* batteries for supplying the filament, plate and grid voltages, respectively, in cases where the A. C. supply is not available.

In cases where very high-speed operation is desired, the ordinary relay may be replaced by one designed for high-speed operation.

PLAINTIFF'S EXHIBIT No. 49

EDITORIAL RECORD

ATOR, BUREAU OF STANDARDS:

I submit herewith for publication the manuscript indicated below, with inclosures. The work was done under Research Authorization No. 27

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To be published as (mark x)

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TITLE OF PAPER

Note on the Development of an Electron Tube Amplifier Using 60-cycle Alternating Current to Supply Power for the Filaments and Plates.

BY AUTHOR P. D. Lowell TITLE OF AUTHOR Associate Physicist

SHORT TITLE (less than 36 letters) for running heads

ABSTRACT (125 words or less, for Cir. 24) Electron tube amplifiers now form an important part of practically all radio receiving sets. Storage cells, which are inconvenient, have heretofore been usually required for operating amplifiers. It would be much more convenient to supply power to an amplifier from 110 volt, 60 cycle mains. A five-stage amplifier has been developed which operates satisfactorily on 60-cycle supply for both filaments and plates. This amplifier has three radio-frequency stages and two audio-frequency stages. Its operating wave length range, as determined by the radio-frequency transformers used, was from 400 to 1500 kilocycles per second(750 to 200 meters)

Signature of Author P. D. Lowell, Title of Author Associate Physicist

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MS. Sent to Department for Printing Mar 9 1927

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PLAINTIFF'S EXHIBIT No. 50

Department of Commerce. Scientific Papers of the Bureau of Standards. S. W. Stratton, Director. No. 450 (part of vol. 18). An electron Tube Amplifier Using 60-Cycle Alternating Current to Supply Power for the Filaments and Plates, by P. D. Lowell, Associate Physicist, Bureau of Standards. October 2, 1922.

AN ELECTRON TUBE AMPLIFIER USING 60-CYCLE ALTERNATING CURRENT TO SUPPLY POWER FOR THE FILAMENTS AND PLATES

By P. D. Lowell

ABSTRACT

Electron tube amplifiers now form an important part of practically all radio receiving sets except the most simple types. Storage cells, which have heretofore usually been required for operating amplifiers, require constant attention, are bulky and heavy, and have other serious disadvantages. The dry cells, which are often used as a source of plate voltage, have a comparatively short life and are expensive and inconvenient. It would be much more convenient to use an amplifier which could be supplied with power from 110-volt, 60-cycle mains for both filaments and plates.

This paper describes a five-stage amplifier, which operates satisfactorily on 60-cycle supply, for both filaments and plates. This amplifier has three radio-frequency stages and two audio-frequency stages, and uses a crystal detector. A special transformer with five windings is used, the primary being supplied with 110 volts alternating current. The 60-cycle current, when used in an ordinary amplifier circuit, introduces a strong 60-cycle note which offers serious interference. This has been practically eliminated by balancing resistances, grid condensers, and special grid leaks of comparatively low resistance, telephone transformer in the output circuit, and crystal detector instead of electron tube detector. In the final form of the amplifier there is only a slight residual hum, which is not objectionable. The amplification obtained with alternating-current supply was as good as that obtained with the same amplifier used with direct-current supply. The complete unit is light, compact, and portable. For the reception of damped waves, the amplifier as constructed operated most satisfactorily for wave lengths from 200 to 750 meters. This range was determined by the working range of the radio-frequency transformers used. By using suitable radio-frequency transformers, it is expected that the amplifier will be effective for the reception of damped waves and undamped waves

PLAINTIFF'S EXHIBIT NO. 50—Continued

as long as 10,000 meters. For the reception of undamped waves, a separate heterodyne should be employed. The paper gives circuit diagrams and states the values of the condensers, resistors, and inductors used. The paper also describes a method for rectifying the 110-volt alternating-current supply and using it for the field of a loud speaker.

Electron tube amplifiers form an important part of practically all radio receiving sets now, except the most simple types. Such amplifiers are, in fact, necessary to receive distant stations, or when using coil antennas. For good operation, amplifier tubes require for the filament a source of voltage of very constant value (usually about 6 volts), and for the plate a source of voltage of from 40 to perhaps 300 volts. The filament voltage is usually supplied by storage cells and the plate voltage by dry cells. The maintenance of

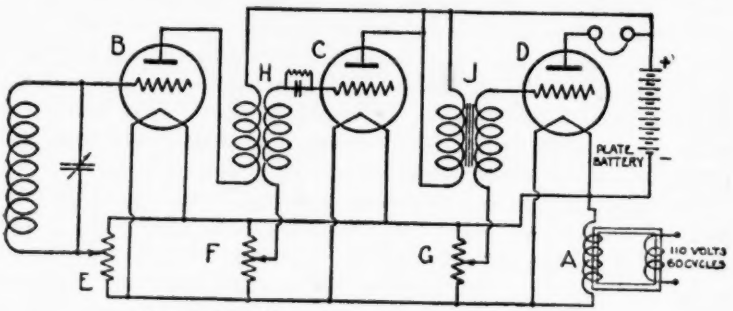


FIG 1.—Two-stage amplifier circuit using tube detector

these cells in operating condition, especially the storage cells, is often a source of much difficulty and annoyance. The storage cells are necessarily bulky and heavy, require constant attention to maintain proper charge and density of electrolyte, give off injurious acid or other fumes, and are subject to variations of voltage during the period of discharge. The development of an amplifier which can be supplied from the ordinary 110-volt alternating-current lighting mains is of considerable practical importance, since it would eliminate the practical difficulties of maintaining storage cells. The amplifier using such alternating-current supply has the important advantages of reliability, convenience, and cheapness both in first cost and operating cost.

With alternating-current supply the expense of the storage battery and its charging equipment and the expense of the dry battery for the plate are eliminated. The first cost of the amplifier with alternating-current supply is somewhat less than the first cost of the

PLAINTIFF'S EXHIBIT No. 50—Continued

ordinary amplifier, including its necessary batteries and charging equipment. One of the most important items in the maintenance cost of the ordinary amplifier is the dry cells for the "B" battery, since in service these dry cells must be renewed about every three to six months. It is estimated that during a period of five years the saving in the cost of "B" dry batteries will alone pay for a complete amplifier with alternating-current supply.

An amplifier with alternating-current supply, using five stages of amplification, has been developed at the Bureau of Standards. There are three stages of radio-frequency amplification and two stages of audio-frequency amplification. This paper describes this amplifier briefly.

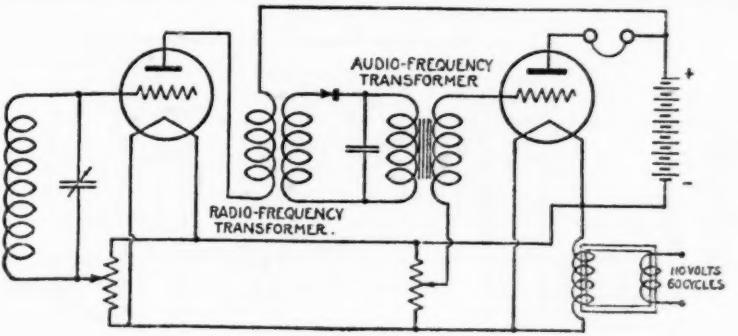


FIG. 2.—Two-stage amplifier using crystal detector

The first arrangement tried consisted of one radio-frequency stage of amplification, tube detector, and one audio-frequency stage. The filaments of the three tubes were lighted by 6 volts supplied by a step-down transformer, the primary of which was connected to the 110-volt, 60-cycle power mains. The circuit is shown in Figure 1.

In Figure 1, the filament lighting transformer is shown at *A*, supplying voltage for the filaments of electron tubes *B*, *C*, and *D*.

The amplifier input circuit is connected to the grid of tube *B* and to the slider of the balancing resistance *E*, the latter having a resistance of 200 ohms and being connected across the filament line. A radio-frequency transformer is shown at *H*, a balancing resistance at *F*, an audio-frequency transformer at *J*, and another balancing resistance at *G*. The purpose of the balancing resistances *E*, *F*, *G*, is to keep the normal voltage of the grids at a steady value with respect to the average voltage of the electrical midpoint of the filament, and to thus eliminate the hum which variations of the grid voltage would cause. These balancing resistances are adjusted until

PLAINTIFF'S EXHIBIT No. 50—Continued

the hum is eliminated. Reception was accomplished with this circuit, but there was considerable 60-cycle hum present in spite of the beneficial effect of the balancing resistances.

The employment of a crystal detector in place of the electron tube detector reduced the 60-cycle hum very considerably. This circuit is shown in Figure 2.

When an electron tube is used as the detector, there is impressed on both the plate and the filament a 60-cycle alternating-current voltage which, although small, becomes very objectionable when amplified by one or two stages of audio-frequency amplification. When the crystal detector is used, no 60-cycle voltage is supplied to the detector circuit. The radio-frequency transformer, whose output is delivered to the detector circuit, prevents the passage in

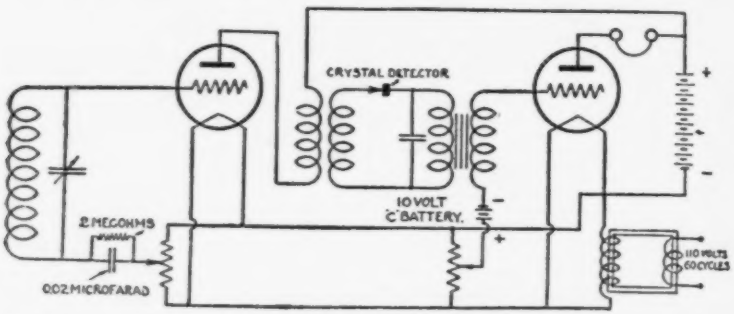


FIG. 3.—Two-stage amplifier using crystal detector, with grid condenser for radio stages and grid battery for audio stages

any appreciable amount of 60-cycle current supplied to the radio-frequency stage, and such voltages are not present in the crystal detector circuit and do not reach the input of the audio-frequency stage.

The employment of a crystal detector may at first seem objectionable, due to the fact that as ordinarily used it is rather difficult to find a point of good sensitivity. But tests on this amplifier showed that careful adjustment of the crystal detector was not necessary because of the fact that the radio-frequency amplification preceding the detector usually gave sufficient signal strength so that a point of sufficient sensitivity could be easily found.

This circuit gave quite good results. The 60-cycle hum was practically eliminated and the crystal detector gave almost as good rectification as the tube detector.

It was found that better amplifying action could be obtained by inserting condensers of about 0.02 microfarad capacity, shunted by

PLAINTIFF'S EXHIBIT No. 50—Continued

two megohn grid-leak resistances, in the grid circuits, in series with the sliders of the balancing resistances. The grid condensers and grid-leak resistances allow the grids to assume a normal voltage which is more favorable for amplifying purposes. The leak resistances allow any accumulated charge on the grids to leak off to the filaments. Still better amplification and quieter operation was produced by replacing the series grid condenser and leak in the audio stage with a 10-volt battery giving a negative charge to the grid. A battery of dry cells was used for this purpose; since only an extremely small current is required, the life of the dry cells is practically their shelf life. This gave a circuit as shown in Figure 3.

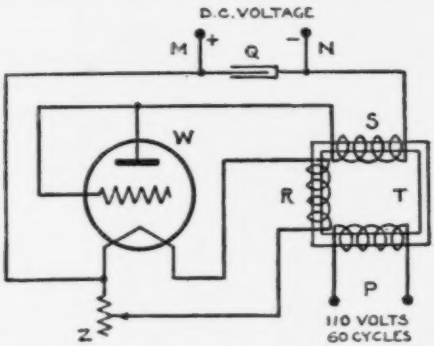


FIG. 4.—Rectification circuit for plate voltage supply

Alternating current rectified by means of a gas-filled two-element rectifier tube ("Tungar" tube) was tried as a source of filament power, but the residual hum was much greater than when unrectified alternating current was used. This is because of the fact that during rectification the wave form becomes distorted and it becomes impossible to stabilize the grid voltage by means of the balancing resistances.

In the above-mentioned tests a plate battery was used for convenience, but this was replaced by alternating current which had been rectified by means of an electron tube and smoothed out with condensers of large capacity. The rectification circuit for the plate voltage supply is shown in Figure 4.

In Figure 4 the primary *P* of the transformer *T* is connected to the power mains, and the winding *R* gives 8 volts for the filament of the rectifier tube *W*. Winding *S* gives 300 volts, which is rectified by the tube *W* and smoothed out by the condenser *Q*, which has about 10 microfarads capacity. This gives at terminals *M* and *N* a high-

PLAINTIFF'S EXHIBIT No. 50—Continued

FIG. 5.—*Final complete circuit of five-stage amplifier, using crystal detector and 60-cycle alternating current to supply power for the filaments and plates.*

PLAINTIFF'S EXHIBIT No. 50—Continued

voltage direct current which is quite suitable for use on the plates of the amplifier tube. Rheostat *Z* varies the brilliancy of the filament of the rectifier tube and, simultaneously, the voltage for the plates.

The use of a loud-speaking telephone receiver, such as the "Magnavox," was made possible by applying to the field coil of the loud speaker an alternating current rectified by a "Tungar" rectifier tube. The impedance of the field coil was sufficient to smooth out the pulsating current to such an extent that the hum was not annoying. It was also advantageous to couple the loud-speaking reproducer circuit to the plate circuit of the last amplifier tube by means of a one-to-one ratio telephone transformer with a 0.02 microfarad condenser in series with the telephone circuit. This helped considerably to reduce the residual hum in the telephone.

The final circuit is shown in Figure 5, and includes three stages of radio-frequency amplification, galena crystal detector, two stages of audio-frequency amplification, loud-speaking reproducer, and the necessary power transformer and rectification circuits.

This final circuit gives good amplification, with a slight residual hum, which is not great enough to be objectionable, when receiving signals of ordinary readable strength. The residual hum is, of course, more objectionable when extremely weak signals are being received. Radiotelephone music and conversation are clearly reproduced.

The amplifier was operated under normal conditions, using the usual sources of direct-current supply, and then switched over to alternating-current supply. This comparative test showed the alternating-current supply to give as good amplification as the direct-current supply, although the set was slightly more sensitive to weak signals when batteries were used, on account of the interference caused by the hum when used on alternating current.

For the reception of damped waves, the amplifier as constructed operated most satisfactorily for frequencies from 400 kilocycles to 1,500 kilocycles per second (750 to 200 meters). This frequency range was determined by the working range of the radio-frequency transformers used. By using suitable radio-frequency transformers, it is expected that the amplifier will be effective for the reception of damped waves for frequencies as low as 30 kilocycles (10,000 meters). This amplifier has also been found effective for the reception of undamped waves, when used with a separate heterodyne.

The special transformer with five windings and the rectifier tube were assembled in one box, and the amplifier tubes and amplifier transformers and other apparatus were assembled in a separate box.

PLAINTIFF'S EXHIBIT NO. 50—Continued

This was done to avoid having the amplifier immediately adjacent to the special transformer, from which it would pick up considerable 60-cycle hum. The assembled rectifier unit measured about 8 by 8 by 9 inches and weighed about 21 pounds. The assembled amplifier unit measured about 8 by 11 by 14 inches and weighed about 21 pounds.

Figure 6 shows the rectifier unit and the amplifier unit as completed, with the plug to connect with the 60-cycle lighting current. A 6-inch rule is shown leaning against the rectifier unit.

F. W. Dunmore was a coworker and participated in the development of this instrument.

WASHINGTON, *June 17, 1922.*

PLAINTIFF'S EXHIBIT NO. 51

LEW:AN

RADIO LABORATORY,
BUREAU OF STANDARDS,
May 2, 1921.

RADIO RESEARCH PROBLEMS SUGGESTED TO THE AIR SERVICE

1. Radio direction finding in aerial navigation.

The use of the radio direction finder on aircraft including the study and comparison of fixed and rotating coils, the use of rotating coupler, single coils and combinations of two or more coils. The study of the distortion of radio waves in the vicinity of guy wires and motors.

2. Elimination of ignition interference.

The oscillographic study of the current in the ignition system and the field surrounding the ignition circuits. Comparison of insulated and ground spark plug circuits, and experimental study of various methods for eliminating or minimizing ignition interference such as the use of symmetrical coil aerials, compensating coils, the tuning of the ignition system, the use of shielding and remote control of the ignition circuits, and the use of filter circuits in the radio receiving set.

3. Visual indicator.

The development of a means by which the pilot can receive visual indication that the signals are above a certain intensity or a visual indication of the direction from which the signals are being received. A study of electron tube receiving apparatus and amplifiers together with suitable relays for use in the output circuit and the combination of such apparatus with the particular receiving or direction finding aerial which may be adopted.

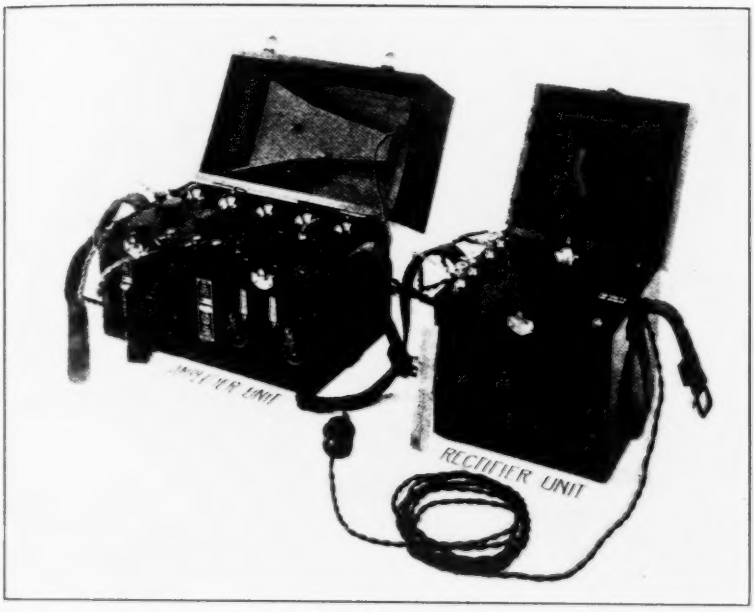


FIGURE 6.—Amplifier and rectifier unit

PLAINTIFF'S EXHIBIT NO. 51—Continued

4. Electrical altimeter for aircraft.

The initiation of experiments on radio or other electrical methods for determining the height above the ground. The variation of the capacity of a condenser antenna or the variation by any other means of the frequency of the current generated by a radio generating set as the airplane or airship approaches the ground.

5. Antenna constants.

The development of methods of measurement and the determination of definitions of the constants of antennas with particular attention to antennas applicable to aircraft such as trailing wire, coil, skid-fin, condenser antenna, etc.

6. Radio ground speed indicator.

Experiments in the use of the Doppler effect using radio waves, there being two transmitting stations whose signals would be received simultaneously on the airplane. The beat frequency observed would depend upon the speed of the plane with respect to the ground.

7. Determination of position of aircraft by ground stations.

The use of radio direction finding stations on the ground so arranged to receive signals from aircraft on the Washington-Dayton model aerial highway or other suitable course, the position and course travelled being determined by radio bearings and plotted on charts. This study should include the determination of the direction of waves received from aircraft at various heights and the precision with which such observations can be made.

8. Airship bomb control and marine torpedo control by radio.

Study and criticism of the circuits and apparatus which have so far been developed for this purpose. The development of a suitable relay for use with electron tube receiving circuits, study of the constancy and uniformity of electron tubes and other parts of apparatus for radio control use.

9. Transmission of directed radio waves from ground.

Study of the field radiated from various types of antennas with especial attention to the development of antennas for transmitting waves upward or for transmitting waves in a horizontal line or in a single horizontal direction. The use of a captive balloon carrying suitable apparatus for measuring the signal intensity and thus determining the radiated field from the antennas studied.

PLAINTIFF'S EXHIBIT No. 51—Continued

10. Linkage between radio stations and wire telephone lines.

The study and development of suitable apparatus whereby a telephone subscriber may converse with the pilot of an airplane or airship in flight. This would include the study of suitable transformers and switching devices and the development of an automatic break-in system for changing from transmitting to receiving.

11. Aircraft radio information.

Compilation of bibliographies on aircraft radio problems and the study and standardization of the terminology used in aircraft radio. The coordination of information regarding various kinds of radio apparatus developed for aircraft in this country and abroad, including descriptions, photographs, data, and summaries of performance tests. The representation of Air Service interests and of commercial aviation in the International Union for Scientific Radio Research and in the International Radio Convention. Technical advice regarding aircraft radio problems including criticism of methods and design, coordination of the interests concerned in the establishment of a network of radio beacon and broadcasting stations over the United States.

12. Radio telephone transmitting sets.

Testing and development of high-power electron tubes and transmitting sets with especial regard to their use for communication with aircraft. The development of a method for using arc transmitting sets for radio telephony.

13. Materials and parts for transmitting sets.

The study of materials for oscillation transformers, coupling coils, condensers, antenna conductors, insulators, and other parts of radio transmitting sets. The test and criticism of the sets recently developed and in use at the present time. Suggestions regarding simple tests, principles and special features to be considered in the development of efficient transmitting apparatus.

WASHINGTON, D. C.

PLAINTIFF'S EXHIBIT NO. 52

WEEKLY REPORT CARDS OF JOHN P. BUCKLEY

1921

July 4. Designing and drafting: Made four drawings for Mr. Breit; two drawings for Mr. Zahn; three for Mr. Dunmore; supervised work left with machinist and carpenter; in charge of files.

5. "
6. "
7. "
8. "
9. "

18. Designing and drafting: Made ten drawings for Mr. Dunmore; two drawings for Mr. Whittemore; ten drawings for Mr. Breit; four drawings for Mr. Dunmore; altered drawings for Mr. Dunmore; supervised work left with carpenter and machinist; in charge of files.

19. "
20. "
21. "
22. "
23. "

25. Designing and drafting: Made three drawings for Mr. Ould; five drawings for Mr. Dunmore; three drawings for Mr. Hall; changing file system to decimal system; supervised work left with machinist and carpenter; in charge of file.

26. "
27. "
28. "
29. "
30. "

Aug. 29. Designing and drafting: Made two drawings for Mr. Dunmore; two drawings for Mr. Strock; one drawing for Mr. Mulligan; radio bldg. wiring; supervised work left with carpenter and machinist; in charge of files.

30. "
31. "

Sept. 1. "
2. "
3. "

PLAINTIFF'S EXHIBIT No. 52—Continued

1921

Sept. 12. Designing and drafting: Made one drawing for Mr. Dunmore; one drawing for Mr. Ould; one drawing for Mr. Mulligan; one for Mr. Whittemore; supervised work left with carpenter and machinist; in charge of files.

13. "

14. "

15. "

16. "

17. "

26. Designing and drafting: Made six drawings for Mr. Bernard; one drawing for Mr. Ould; one drawing for Mr. Dunmore; one drawing for Mr. Mulligan; one drawing for Mr. Hull; supervised work left with carpenter and machinist; in charge of files.

27. "

28. "

29. "

30. "

Oct. 1. "

3. Designing and drafting: Made three drawings for Mr. Hull; two drawings for Mr. Dunmore; three drawings for Mr. Mulligan; one drawing for Mr. Willoughby; supervised work left with carpenter and machinist; in charge of files.

4. "

5. "

6. "

7. "

8. "

17. Designing and drafting: Made two drawings for Mr. Dunmore; one for Mr. Cox; two drawings for office (Miss Noel); two drawings for Mr. Ould; one for Mr. Mulligan; supervised work left with carpenter and machinist; in charge of files.

18. "

19. "

20. "

21. "

22. "

PLAINTIFF'S EXHIBIT No. 52—Continued

1921

Oct. 24. Designing and drafting: Made three drawings for Mr. Ould; two drawings for Mr. Dunmore; one drawing for Mr. Willoughby; one drawing for Mr. Mulligan; six drawings for Mr. Whittemore; one drawing for Mr. Hall; supervised work left with carpenter and machinist; in charge of files.

25. "

26. "

27. "

28. "

29. "

31. Designing and drafting: Made two drawings for Mr. Dunmore; two drawings for Mr. Preston; one drawing for Mr. Ould; two drawings for Mr. Mulligan; supervised work left with carpenter and machinist; in charge of files.

Nov. 1. "

2. "

3. "

4. "

5. "

7. Designing and drafting: Made one drawing for Mr. Lowell; two drawings for Mr. Preston; four drawings for Mr. Kruse; in charge of files.

8. "

9. "

10. "

11. "

12. "

21. Designing and drafting: Made two drawings for Mr. Ould; four drawings for Mr. Dunmore; one drawing for Mr. Cox; four drawings for Mr. Willoughby; in charge of files.

22. "

23. "

24. "

25. "

26. "

PLAINTIFF'S EXHIBIT No. 52—Continued

1922

Jan. 2. (Holiday). Designing and drafting: Made three drawings for Mr. Dunmore; one drawing for Mr. Willoughby; arranged files.

3. "

4. "

5. "

6. "

7. "

23. Designing and drafting: Made one drawing for Mr. Ould; two drawings for Mr. Cox; one drawing for Mr. Dunmore; worked on drawings of decremeter; in charge of files.

24. "

25. "

26. "

27. "

28. "

30. Designing and drafting: Made one drawing for Mr. Dunmore; six drawings for Mr. Lowell; five drawings for Mr. Ould; in charge of files.

31. "

Feb. 1. "

2. "

3. "

4. "

13. Designing and drafting: Made one drawing for Mr. Dunmore; six drawings for Mr. Lowell; five drawings for Mr. Ould; fifteen drawings for Mr. Cox; in charge of files.

14. "

15. "

16. "

17. "

18. "

20. Designing and drafting: Made two drawings for Mr. Mormon; four drawings for Mr. Ould; four drawings for Mr. Preston; five drawings for Mr. Lowell; in charge of files.

21. "

22. "

23. "

24. "

25. "

PLAINTIFF'S EXHIBIT No. 52—Continued

1922

Mar. 6. Designing and drafting: Made one drawing for Mr. Dunmore; two drawings for Mr. Whittemore; seventeen drawings for Mr. Harmon; in charge of files.
7. "
8. "
9. "
10. "
11. "

Apr. 10. Designing and drafting: Made two drawings for Mr. Dunmore; one drawing for Mr. Preston; Strock, 2 drawings; ten drawings for Mr. Harmon; in charge of files.
11. "
12. "
13. "
14. "
15. "

May 1. Designing and drafting: Made seven drawings for Mr. Ould; one drawing for Mr. Dunmore; worked on drawings for decremeter; in charge of files.
2. "
3. "
4. "
5. "
6. "
22. Designing and drafting: Made one drawing for Mr. Dunmore; altered eight drawings for Mr. Ould; continued work on decremeter.
23. "
24. "
25. "
26. "
27. "

June 12. Designing and drafting: Completed drawing of decremeter; lettered 131 photos; made two drawings for Mr. Dunmore; one drawing for Mr. Harmon; in charge of files.
13. "
14. "
15. "
16. "
17. "

PLAINTIFF'S EXHIBIT No. 52—Continued

1922

June 19. Designing and drafting: Made 2 drawings for Mr. Dunmore; lettered signs for Mr. Noel; 1 drawing for Mr. Engel; checked decremeter drawings with Signal Corps officer; in charge of files.

20. "

21. "

22. "

23. "

24. "

26. Designing and drafting: Made three drawings for Mr. Harmon; one drawing for Mr. Cox; four drawings for Mr. Ould; one drawing for Mr. Dunmore; in charge of files.

27. "

28. "

29. "

30. "

July 1. "

10. Designing and drafting: Made one drawing for Mr. Harmon; one drawing for Dr. Dellinger; three drawings for Mr. Wheeler; one drawing for Mr. Dunmore; one drawing for Mr. Whittemore; in charge of files.

11. "

12. "

13. "

14. "

15. "

17. Designing and drafting: Made one drawing for Mr. Dunmore; two for Mr. Ould; three drawings for Mr. Preston; in charge of files.

18. "

19. "

20. "

21. "

22. "

In the District Court of the United States for the District of Delaware. United States of America *v.* Dubilier Condenser Corporation, Plaintiff's Exhibit Buckley I.

R. W. LEE, *Notary Public.*

PLAINTIFF'S EXHIBIT NO. 53

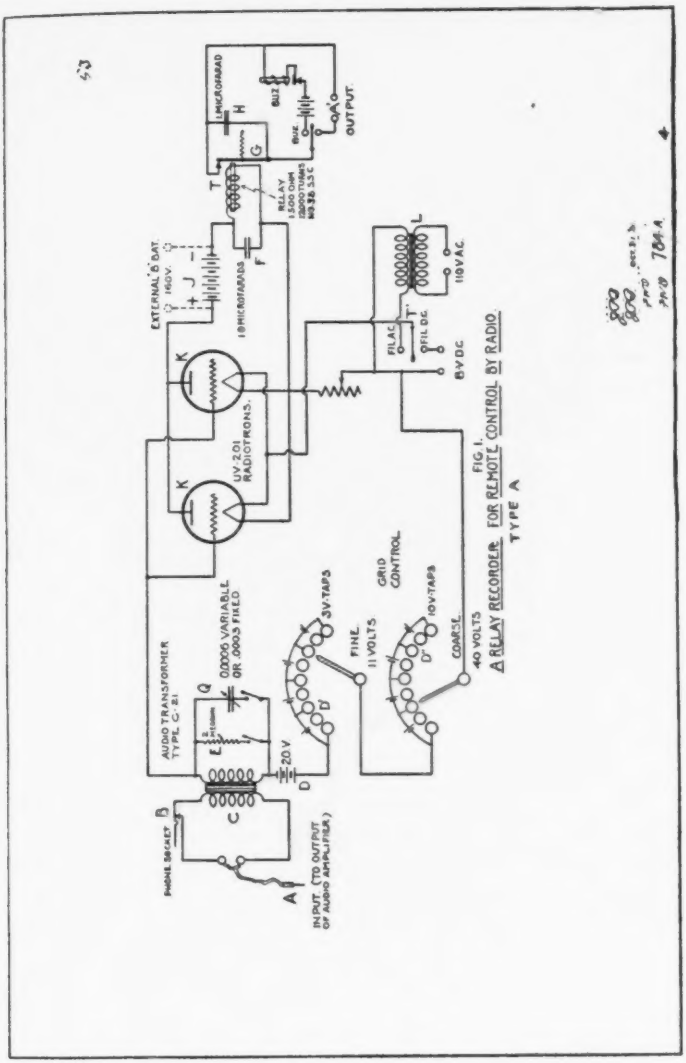


FIG I.
A RELAY RECORDER FOR REMOTE CONTROL BY RADIO
TYPE A

PLAINTIFF'S EXHIBIT No. 54

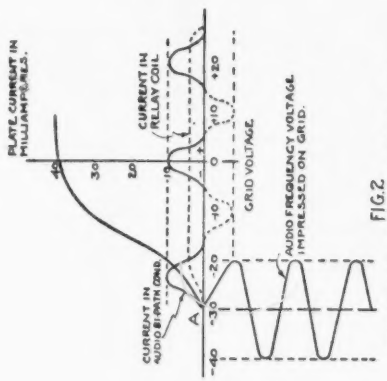


FIG. 2
TUBE CHARACTERISTIC FOR RELAY FOR REMOTE CONTROL BY RADIO.

BUREAU OF STANDARDS
7848

PLAINTIFF'S EXHIBIT No. 55

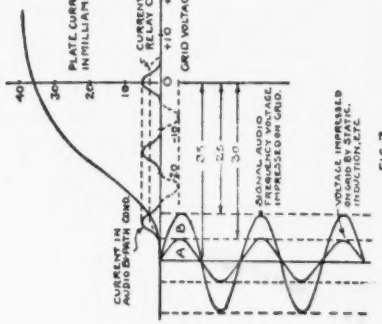


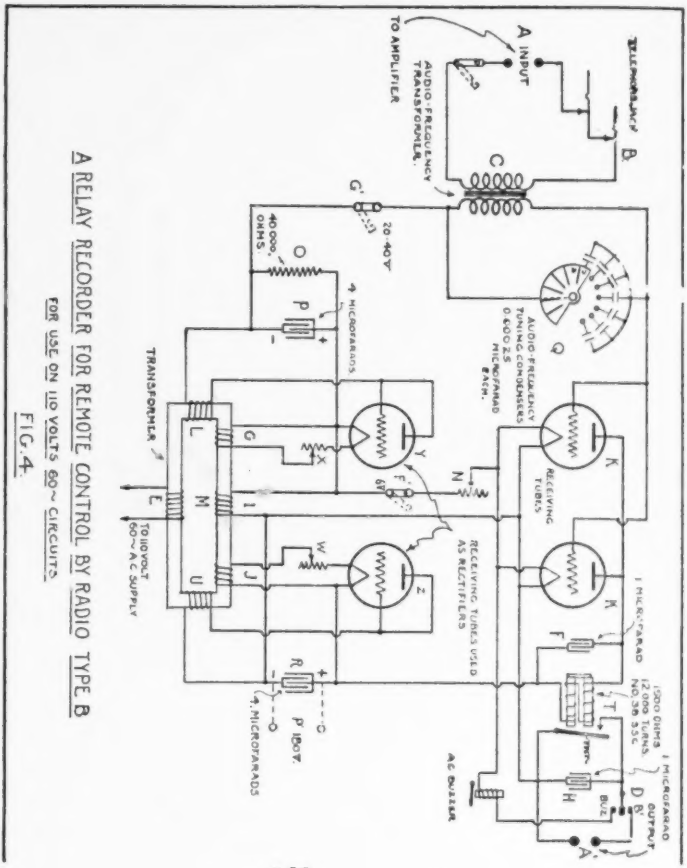
FIG. 3.

TUBE CHARACTERISTIC FOR RELAY FOR REMOTE CONTROL BY RADIO.

METHOD OF ELIMINATING STATIC, INDUCTION ETC. WHICH IS NOT STRONGER THAN THE SIGNAL, BY PROPER ADJUSTMENT OF GRID VOLTAGE.

784-C

PLAINTIFF'S EXHIBIT NO. 56



A RELAY RECORDER FOR REMOTE CONTROL BY RADIO TYPE B

FOR USE ON 110 VOLTS 60~ CIRCUITS

FIG. 4

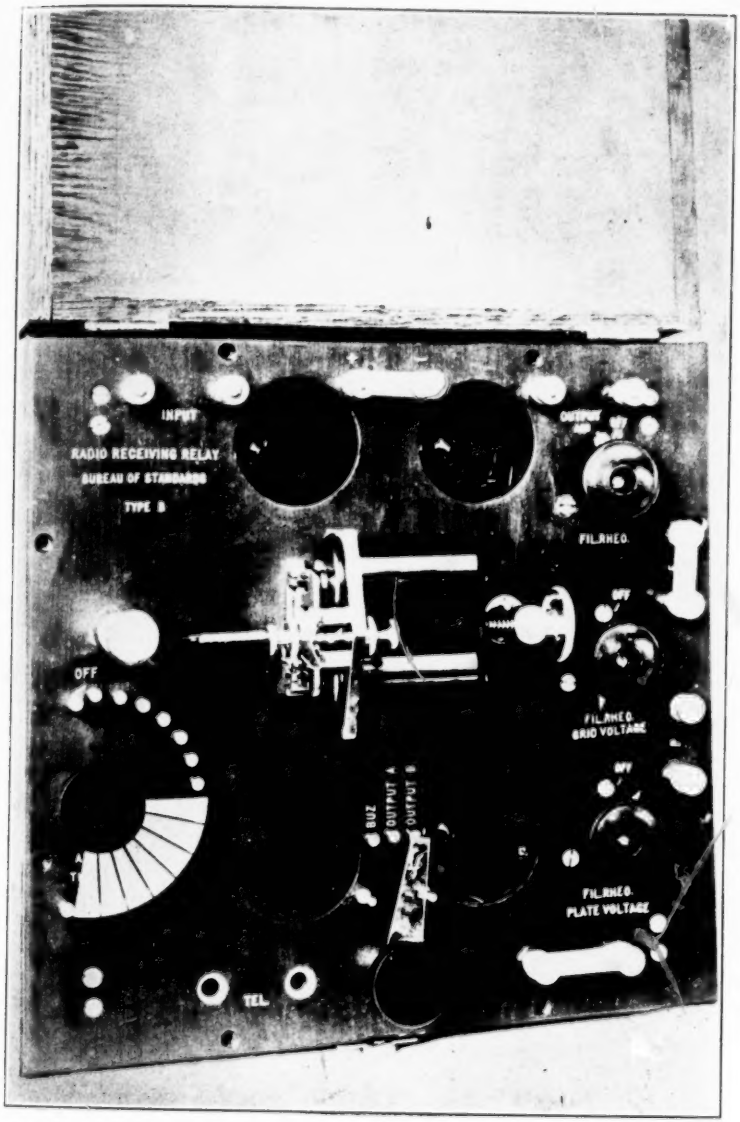
DEC 31 1921

891

6

Plaintiff's Exhibit No. 58

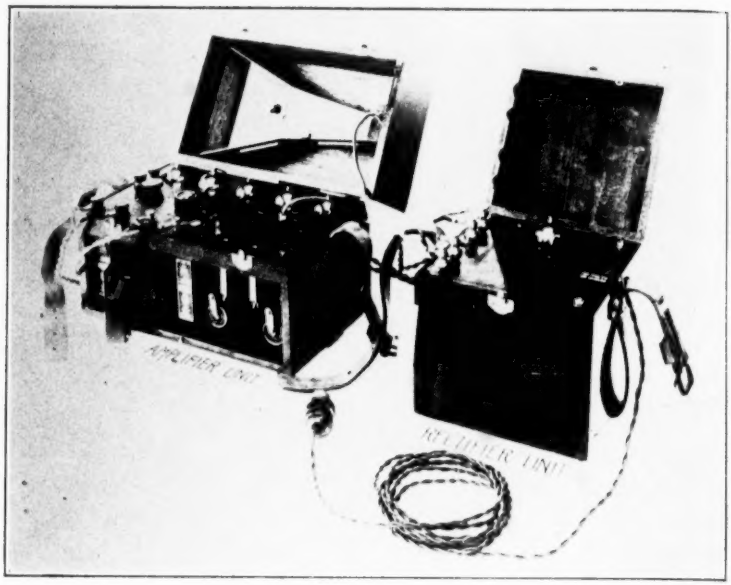
TYPE B RADIO RECEIVING RELAY.



388—1

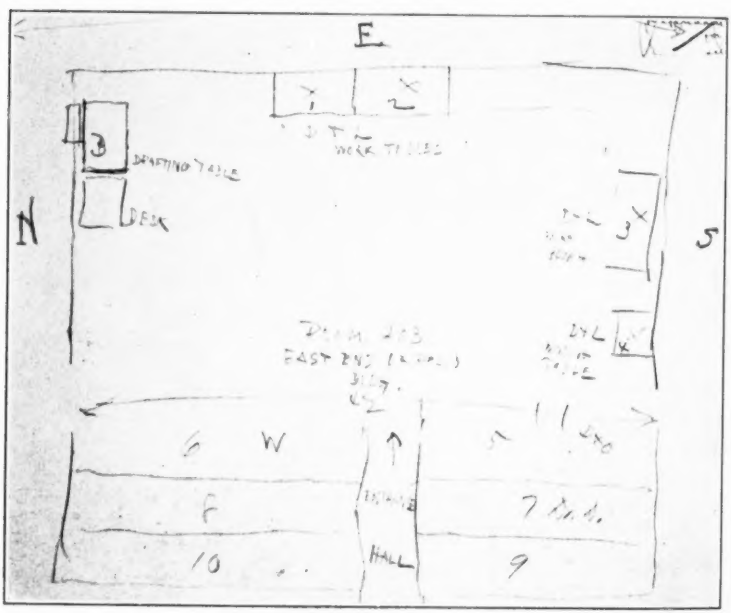
PLAINTIFF'S EXHIBIT NO. 59

AMPLIFIER AND RECTIFIER UNIT.



PLAINTIFF'S EXHIBIT NO. 60

BUCKLEY SKETCH OF OFFICE LAYOUT, BUREAU OF STANDARDS.



PLAINTIFF'S EXHIBIT No. 57

(Same as Plaintiff's Exhibit No. 50)

PLAINTIFF'S EXHIBIT No. 61

FWD: MHC

JULY 26, 1921.

CHIEF, EQUIPMENT SECTION, NAVIGATION BRANCH,
Air Service, War Department,
McCook Field, Dayton, Ohio.
(Through A. S. Rep., Bureau of Standards.)

Subject: Airplane radio problems.

DEAR SIR: The progress of this month's work is reported herewith as follows:

1. Elimination of ignition interference. This is made the subject of a special report, a copy of which is attached.

2. Equi-signal double-coil directional transmission tests. Due to the fact that the personnel connected with this work were on leave, and that it is being taken over by the Air Service at Dayton, where the facilities are much better, but few experiments were conducted. Tests were, however, made to investigate the effect noted in the air during last month's tests. This change of relative signal intensity from the two coils, as the plane flew at right angles to the line of direction to the transmitting coils, was mentioned in our last report. To investigate this effect further two low inverted L antennas 8 feet high and 150 feet long were put up seven miles from the double-coil transmitter. These antennas were mounted so that one extended to the east, the other to the west; the coil transmitter hung due south. A D. P. D. T. switch was arranged to throw each antenna alternately on the antennas. A common ground was used. The antennas were located about two miles west of the equi-signal line. On listening to the A–T signals from the two transmitting coils it was found that A was about the same intensity on each antenna but that T was considerably louder on the antenna with the free end pointing east. On both antennas T was louder than A. These tests confirmed the effect noted on a plane.

A trip was made to McCook Field by Messrs. Whittemore, Zahn, and Engle to study the present status of work there and to confer regarding future work on the navigation program.

Respectfully,

(Sgd.) S. W. STRATTON,
Director.

Enclosure: cR521.3c.

PLAINTIFF'S EXHIBIT No. 61—Continued

FWD:MHC

JULY 25, 1921.

CHIEF, EQUIPMENT SECTION, NAVIGATION BRANCH,
Air Service, War Department,
McCook Field, Dayton, Ohio.
(Through A. S. Rep., Bureau of Standards.)

Subject: Airplane radio compass.

DEAR SIR:

1. As arranged by Mr. Whittemore during his recent visit to Dayton, various design work is to be undertaken in connection with the installation of a direction-finder coil and associated equipment on the Martin bombing type of aeroplane. This equipment will be made in the shops of this laboratory and shipped to Dayton for test.

2. It will be necessary that we know some of the dimensions of various fuselage stations of these ships before proceeding. We request, therefore, that you be good enough to forward any drawings which you may be able to spare, in order that this apparatus be installed in the ships at Dayton with the least possible alteration.

3. Information is also requested relative to the wave-length range required for this work. The radio compass is greatly simplified by keeping this range as small as possible. It is suggested that the wave lengths used be kept within the limits of the wave-length range of any one of the radio frequency amplifiers now available.

Respectfully,

(Sgd.) S. W. STRATTON, *Director.*

FWD:MHC

MARCH 24, 1921.

EQUIPMENT SECTION, NAVIGATION BRANCH,
Air Service, War Department,
McCook, Field, Dayton, Ohio.

Subject: Progress report on aerial navigation problem.

GENTLEMEN:

1. We submit the following as a report on the progress of this month's work:

Experiments on directive transmission from crossed-coil aerials have been performed and give promise of success as a means of guiding an airplane. The method requires no other than the ordinary radio receiving set with trailing antenna aboard the plane. This system, suggested by our Mr. Lowell, consists briefly of transmission alternately from two coil aerials crossed at an angle of 135 degrees and tuned to the same wave length. These coils are oriented so that the bisector of the 135° angle is along the line of flight or the

PLAINTIFF'S EXHIBIT No. 61—Continued

aerial highway route. The letter R is sent from one coil and L from the other, and these signals are picked up by the plane on the ordinary receiving set. As long as the signal intensity of the letter R equals that of L the plane is on the course. Should R become louder than L the plane should turn to the right to get back on the route. This is the proposed method of operation.

Tests have already been made with two eight-foot eight-turn crossed coils using 1,000 meters. The results when receiving at a distance of 3 miles were so encouraging as to warrant a more extensive investigation. Two larger coil frames 18 feet square have been built up and wound with two turns of wire.

Transmission tests from one of these coils has been made at 440 meters wave length. The transmitting current was 4 amperes. The signals were received at a distance of 3 miles. As the transmitting loop was rotated it was noted the signal intensity at the receiving end varied approximately the same as when a receiving coil aerial is rotated. The minimum was sharp, the signal going entirely out as the rotation passed through the minimum point. This showed the antenna effect of the transmitting aerial to be negligible as a 6-step amplifier made for 440 meters was used at the receiving end. Reception was done on a 4-foot coil. The signal intensity on the maximum signal was sufficient to be heard at a distance of a hundred feet from the phones. These tests at 3 miles are not of course absolutely conclusive as to results at greater distances.

2. It is expected that in next month's report we will be able to give results of tests with the two 18-foot coils. Reception tests will be made at distances up to 40 miles, the letter A being sent on one coil, the letter T on the other.

Respectfully,

(Sgd.) S. W. STRATTON,
Director.

FEBRUARY 19, 1921.

EQUIPMENT SECTION, NAVIGATION BRANCH,
Air Service, War Department,
McCook Field, Dayton, Ohio.

Subject: Progress report on aerial navigation problem.

GENTLEMEN:

1. We submit herewith the following as a report on the progress of this month's work:

DIRECTION-FINDER PROBLEMS

The study of the various methods of utilizing fixed crossed coils on the wings of a plane has been continued. A method which seems

PLAINTIFF'S EXHIBIT NO. 61—Continued

promising consists of a set of crossed coils on each wing, like coils being connected in series forming the equivalent of one set of coils crossed at an angle of 45°, the 45° angle being at an angle of 90° to the fore and aft line of the plane. The coils are connected alternately onto one tuning condenser, provision being made so that the adjustment of this condenser is the same for each coil. A bearing is taken when signals of equal intensity are heard at both positions of the change-over switch. Balancing condensers are used on each coil to compensate for dissymmetry in capacity from the two loop terminals to the metallic work of the plane. Two, and not one, set of crossed coils are used to improve the electrical symmetry, which is so important for accurate direction-finder work. The 45° angle was found to make possible the most accurate bearings, as the change in signal intensity with respect to angular rotation is greater with this angle than with the 90° angle, although the signal is not quite as strong. This also gives a working angle of 135° as compared to 90°.

It was found that the two coils connected in series and placed diagonally between the two struts on each wing of the Breguet plane (forming the one set of the crossed coils mentioned above) should have about 8 turns each with ½" spacing in order to tune to approximately 1,000 meters with the ordinary type of air condenser.

Due to the fact that the Breguet plane was set up indoors, actual direction-finding work was impractical, as the plane could be rotated through but a small angle and the building acted more or less as a shield for outside signals.

A special type of coupling coil between the tuning condenser and amplifier has been found advantageous both in maintaining electrical symmetry and eliminating the troublesome click in the phones when the change-over switch is operated. It is also valuable in eliminating ignition noises, etc.

The study of shielding was conducted with a dummy ignition system on the plane. This consisted of a shielded box containing the battery, induction coil, etc. With this apparatus the spark could hardly be heard in the phones of the receiving set. If the ignition battery was brought near the receiving set, the spark could be heard very readily. A method of tuning this dummy ignition system was tried and seemed to offer some possibilities.

It would seem that the combination of shielding, proper location of ignition wires, coupling coil, balancing out or pick-up coils, and possibly tuned ignition circuits might serve to eliminate to a great extent any interference from the ignition system. Further work on this phase of the problem should be done on a plane with engine in running order.

PLAINTIFF'S EXHIBIT No. 61—Continued

LANDING SIGNAL SYSTEM

Some laboratory work has been done along this line which has resulted in a method of using the same coil and amplifier for the landing signal as is used for the radio direction finding signal. This was accomplished by connecting an audio tuned circuit across the loop tuning condenser. This tuned circuit contained the primary of an audio-frequency transformer. This circuit being of high reactance to radio frequencies does not interfere with their reception. The secondary of the audio transformer is shunted by a small condenser, which serves both as a radio-frequency bypath and as a means of tuning the secondary to the audio frequency. The low potential (filament end) of the secondary of the last radio-frequency transformer in the amplifier is disconnected from the filament lead and the secondary of the above audio transformer is put in this break in the circuit. This gives the audio amplification of the detector tube and two audio stages in the amplifier for the amplification of the landing signal. In a laboratory test of this circuit it was easily possible to receive and tune to both a radio and an audio signal at the same time.

2. It would be appreciated if a representative from McCook Field who is familiar with the direction-finding work which is going on there could visit this bureau. Cooperation in work of this nature is of greatest value.

Respectfully,

(Sgd.) S. W. STRATTON,
Director.

I–6 APRIL 20, 1921.

EQUIPMENT SECTION, NAVIGATION BRANCH,
Air Service, War Department,
McCook Field, Dayton, Ohio.

Via liaison officer, room 30, north building, Bureau of Standards.

Subject: Progress report on Aerial navigation problem.

GENTLEMEN: We submit the following as a report on the progress of this month's work.

1. Experiments on directive transmission, as mentioned in our report for March, have been continued and the results obtained, although not conclusive, warrant further investigation along this line. Some work has been done to improve the low radiating efficiency of coil aerials, larger coils now being used. In regard to distance covered we may add that a station in Baltimore, Md. (40 miles distant), is copying our signals. These results were obtained using

PLAINTIFF'S EXHIBIT No. 61—Continued

single-turn coils, or loops, of the approximate dimensions 120′ x 50′ x 30′. With these loops and an input of about 2 k. w., loop currents varying from 4 to 7 amperes were obtained, depending on the manner of connecting and the position of the ammeter in the loop and the wave length used.

2. Consideration has also been given to the practicability of this method as applied to airplane work. From the data obtained during tests this month, possible sources of error, means for their elimination and the probable degree of accuracy of this method have been determined. Relative audibilities of the two loops which are crossed at an angle of 144° have been measured at points about this bureau at a distance of seven miles. These measurements show the existence of an equi-signal zone running through the bisecting angle of the loops as expected. Subsequent measurements made at different points check fairly closely the results previously obtained. Tests thus far seen to indicate that at a distance of 8 miles the signal intensity from the two loops changed from one of equality at the equi-signal point to one double the other at a distance of a quarter of a mile measured along a line at right angles to the direction to the transmitter.

3. Lack of space for larger transmitting coil aerials and lack of a more powerful transmitter prevent any very long distance tests, but with the equipment at hand it is hoped that a thorough study of the transmitting aerial characteristics up to 50 or 60 miles can be made.

Respectfully,

(Sgd.) S. W. STRATTON,
Director.

MAY 25, 1921.

EQUIPMENT SECTION, NAVIGATION BRANCH,
Air Service, War Department,
McCook Field, Dayton, Ohio.

(Via liaison officer, room 30, north bldg., Bureau of Standards.)

Subject: Progress report on aerial navigation problem.

GENTLEMEN:

1. The progress of this month's work is reported herewith, as follows:

1. Directional characteristics of transmitting coil aerial.—The study of the directional characteristics of transmitting coil aerials has been the principal line of investigation this month. This problem is important, as it is upon the development of the best directional transmitting coil that the accuracy and range of the double coil equisignal directional transmitting system depends.

PLAINTIFF'S EXHIBIT No. 61—Continued

In all cases the source of power has been a 2 k. w. 500-cycle quenched gap set. It is well worth mentioning here that such a set when properly coupled to a coil aerial emits a wave of very low decrement; in fact, at the receiving end the tuning is as sharp as with I. C. W. This is an important factor, as in the future when radio beacon stations come more generally into use the problem of interference will be a vital one.

In Fig. 1, print No. 750, is shown one of the circuits tried out. A B C D represents a single-turn loop 150′ x 40′. With this method of placing the coupling in one end and the capacity in the other, it was found that the current in the two vertical sides was unequal, the current being 0.2 ampere in the condenser side CD and 3 amperes in the side AB. This unequal current in the two vertical sides gave poor directional effects, as was expected.

A second circuit which was tried (see fig. 2) gave more promising results. Here the condensers and coupling were placed in one side. It was found that as the wave length was increased the current in the two sides AB and CD approached equality until at 1,000 meters there was only two-tenths of an ampere difference. 1,000 meters is the wave length for beacon use so this effect was very gratifying. It was found that at this wave length which gave nearly equal currents in both sides of the loop, the directional effects were the best.

To further better the current distribution a two-turn 30′ square loop was put up between two telegraph poles which were so placed with respect to the transmitting apparatus that the circuits could be symmetrically arranged as shown in Fig. 2. No directional tests have as yet been made with this loop.

An important point noted in connection with loop work was that directional tests could not be made within the city limits or where telephone and telegraph wires were within four or five hundred feet of the receiving station. Such tests as were made therefore were conducted on country roads where there were no wires.

2. Double coil equisignal tests.—Tests were made with a loop circuit as shown in Fig. 2, two coils being crossed at an angle of 144 degrees. At the wave length used (1,000 meters) a current of nine amperes was obtained with approximately 2 k. w. input.

Results of tests at this wave length checked with those obtained at 8 miles distant, when 240 meters wave length was used, as described in paragraph 2 of our report of April 20, 1921. Receiving was done with a four-foot coil and a six-stage amplifier.

A preliminary test has been conducted during which signals were received on an airplane up to a distance of five miles, the results of

PLAINTIFF'S EXHIBIT No. 61—Continued

which show the equisignal, maximum and minimum points to be present when receiving on a plane as well as when on the ground. This method affords a very effective way of studying the transmitting coil characteristics and will be used as much as possible in the future.

Equisignal tests have just been completed at a distance of 35 miles. These tests proved so successful and the results were so interesting that they are being made the subject of a special report, a copy of which will be forwarded to you when completed. Briefly these tests consisted of receiving the coil aerial signals on a lighthouse tender as it sailed from Washington to Baltimore. At 35 miles an equisignal zone of two miles was passed through. This proved the presence of a guiding zone covering an area of about 2.5 degrees. Two single turn loops as shown in Fig. 2 were used, crossed at an angle of 144 degrees. The wave length was 1,000 meters. With a six-step amplifier and a one-wire antenna on the lighthouse tender the signals at the equisignal zone thirty-five miles from the transmitting loops were sufficiently loud to be heard all over the cabin.

The Bureau of Lighthouses was represented on this trip, as this directional transmission system is applicable for guiding marine navigation.

Respectfully,

(Sgd.) S. W. STRATTON,
Director.

Enclosure: Radio No. 750.

(Confidential—Subject to revision)

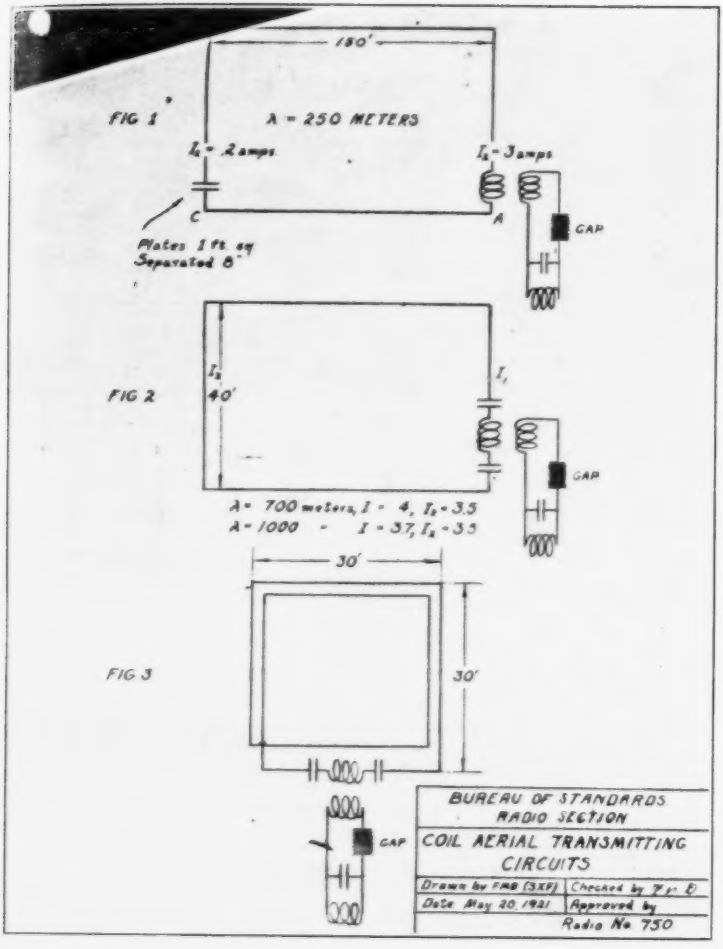
RADIO LABORATORY,
BUREAU OF STANDARDS,
February 13, 1922.

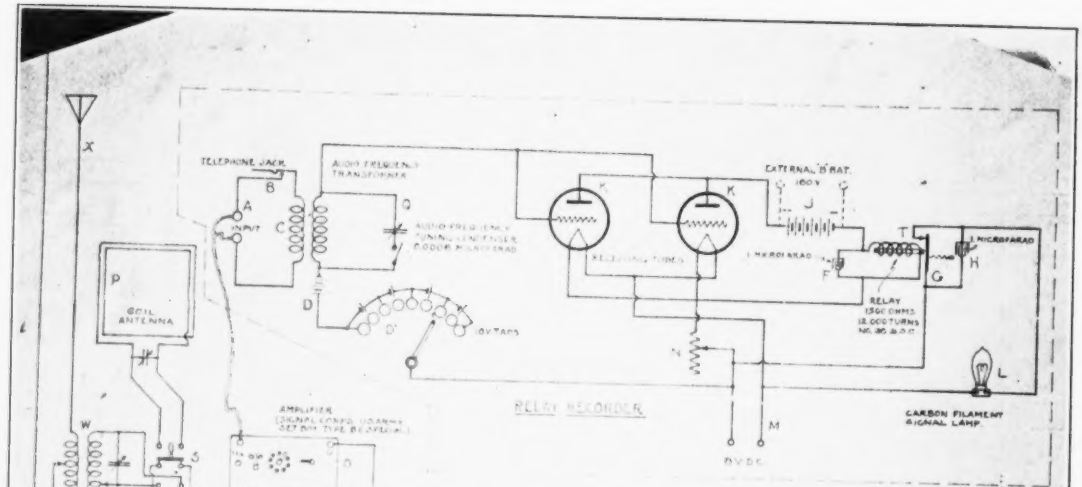
A METHOD OF VISUAL RADIO RECEPTION AND ITS USE ON AIRCRAFT

By F. W. Dunmore, Associate Physicist

On airplanes ear reception of radio signals is very difficult, owing to the excessive noise from the engine. Also the pilot of a one-man plane needs all his senses free to detect any faulty operation of the airplane. This he can not do with head covered over with a receiving helmet. It is therefore desirable that reception be done by visual means.

The type A radio receiving relay recently developed in this laboratory is readily adopted for use on airplanes and may be used to


180'
FIG 1
λ = 250 METERS
I_4 = .2 amps
I_1 = 3 amps
C
A
GAP
Plates 1 ft sq
Separated 8"
FIG 2
I_2
40'
I_1
GAP
λ = 700 meters, I = 4, I_2 = 3.5
λ = 1000 " I = 3.7, I_2 = 3.5
30'
FIG 3
30'
GAP
BUREAU OF STANDARDS
RADIO SECTION
COIL AERIAL TRANSMITTING CIRCUITS
Drawn by FMB (3XF)
Checked by J. E.
Date May 20, 1921
Approved by
Radio No 750



METHOD OF VISUAL RADIO RECEPTION FOR USE ON AIRCRAFT.

BUREAU OF STANDARDS WASHINGTON, D. C.	DRAWN	SCALE	
	TRACED	DATE	
	CHECKED	DRAWING NO.	
DIVISION 1 SECTION 6	APPROVED	893	NO. SHEETS 1 SHEET NO. 1

PLAINTIFF'S EXHIBIT No. 61—Continued

operate a visual signaling device such as an incandescent lamp. A complete description of this relay will be found in radio laboratory report cR367f. The method of using the type A recorder for visual reception is shown in the attached blue print, Radio No. 893. By means of the relay recorder the received signal is made to operate the relay T, which in turn operates the signaling lamp L. The lamp is of the carbon-filament type, which requires an appreciable time to come to full brilliancy. A contact at the relay of short duration will therefore not operate the lamp. Disturbances of this nature do not therefore interfere with reception. Strays often occur for very brief periods, in which case the relay might close the lamp circuit for an instant, but not for a sufficient length of time to operate the lamp. Visual signaling is, of course, slower than aural, but in special cases is more practical.

This relay may be made useful in the solution of project E–23 by adjusting it to operate at a given height (corresponding to a given signal strength). This adjustment could then be changed so that the indicator would operate at a lower height. Thus, the adjustable feature might be calibrated in terms of height above the ground.

It has application also in project E–24. Two relays can be provided, one of which can be connected so that one lamp will light when signals are received from one of the crossed transmitting coils while another lamp will light when signals are received from the other transmitting coil.

Its application to the radio control work of project E–26 has been discussed in the status report dated December 12, 1921.

Aside from the use of visual reception on airplanes it may be used on railroad locomotives and other places where noise is excessive. It may also be used as a call signal.

Attached: Radio No. 893.

WASHINGTON, D. C.

PLAINTIFF'S EXHIBIT No. 62

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
FORM 564

JOB REQUISITION

JOB No. 4022

Required by Div. I-6 MP
Room 207 Bldg. Radio
Approved:

- Electrician
- Superintendent of Plant
- X Chief Mechanician [illegible]
- Woodworker
- Glass blower
- Optician
- Draftsman
- Photographer

Purpose

Requested 1/3/21
Required
Completed

SPECIFICATIONS

State briefly if work is to be of temporary or of permanent construction, accuracy and finish required, or such points which are of importance. Accompany requisition with sketch or drawing. Use separate paper for sketch.

P.W.D: MH

Drilling one panel and as cabling apparatus or panel, for radio receiving relay type "B", on project 42.

Engrave panel for radio set

New date should be
1-3-22

CMK

ESTIMATE

Time $
Material $
Total

Signed
Chief of Shop

Estimate must be obtained in advance from chief of shop before obtaining the approval of the Director

PLAINTIFF'S EXHIBIT NO. 63

Air Service Projects (To chart) 7-2-V 63.

E-21(b) ~~27~~ It would seem wise to me to decide what was personnel we have to the many other problems which are coming to hand, I have no solution as yet It is difficult to work on ignition problems where it is necessary to have the airplane engine running etc. ~~From~~ It is my opinion that this work can be much more effectively done by the Dayton engineers. I think they have also narrowed the solution down as I stated it (Can do nothing further?)

E-22 ~~24~~ I would be a good idea to make ~~such a sketch~~ ~~as soon as~~ I will start work ~~on~~ and set up just as soon as the ~~the~~ several recorders is completed, if ~~necessary~~ being necessary to use time to give the right kind indication upon ~~the~~ them

E-22 ~~25~~. This sketch would be nothing more nor less than a recording set circuit ~~which~~ the output of which was connected to the recorder, the circuit of which could be shown. It is only necessary to put a lamp & battery across the relay to get the manual indication. I'll have this circuit drawn up. Sorrell then

PLAINTIFF'S EXHIBIT No. 63—Continued

suggested a good idea in this connection would be to use a lamp that takes a few seconds to light up, then when the relay chatters due to static it would not hold in contact long enuf to light the lamp, whereas slow sending would- (Worth trying)

E-23
3/1. no tests were made at Canton as per on
2/ the system you outlined. Some apparatus to make possible tests was [illegible] but we have no dope as to means of measuring capacity changes.

The method seems impractical because the capacity between the two plates will be appreciable due to the metallic neighboring parts of the plant. As the change due to the proximity of the ground is comparatively small the change would not be appreciable with the other capacity present. A short wave oscillating circuit with these plates as the capacity with another circuit to give a beat note would be very susceptible to capacity changes but the effects due to the vibration of the frame, the bending of wings etc would be much greater than that produced by the ground some 100 feet distant. The means of measuring the change looks easy, but the other changes of greater magnitude would interfere it would seem. However anything

PLAINTIFF'S EXHIBIT NO. 63—Continued

~~a vertical stay.~~ If his weather permits tho~~se~~ ~~pilots~~ pilots could be driving up on the tilt-over pole over the dash & test made ~~and tilted all indicators during night with aeroplane and~~ subsequent tests could be made ~~same way~~ under actual conditions in aeroplane. ~~not necessarily~~ ~~have with this idea~~

E-24

40. Yes, when I complete the 2nd recorder I ~~can~~ had planned to demonstrate this method of indicating ~~the~~ ~~practical~~ course of the plane. It requires the use of 2 recorders.

E-25 41. I cannot seem to think of any particular things in this connection. ~~They~~ ~~are~~ I have use the personell anyway, consulting the other projects. The PURC is of value to them of course.

E-26 —

Short & set

PLAINTIFF'S EXHIBIT No. 63—Continued

Supplementary Program

JAN 24 1922

E-21(a) 12. — Apparatus should be all ready, and an outline of detailed steps to be taken in the Spring prepared. ~~[illegible]~~ One particular job to be done is the comparison of the several types of d.f.'s that Engel and Snyder did not get to with in Sept.

E-21(b) 17. — Besides the 3 reports mentioned, should not a set of directions be prepared giving best practice for shielding an airplane engine already built?

E-25 44. Lowell's amplifiers (one or more ~~[illegible]~~ at Dayton — valuable)

E-26 Shift-wave generator

~~[illegible]~~

FWD Recorders Required

1 Permanent lab. set
2 Visual indicator
3. Transmitting fabricated waves from ground { 2 sets
4. ~~Airships~~ Aircraft control { How many?

PLAINTIFF'S EXHIBIT No. 63—Continued

JAN 24 1922

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

ADDRESS REPLY TO BUREAU OF STANDARDS

Air Service Radio Projects.

E-21(d)
No 37

Work on this problem will be held up until after the winter months

E-21(dr)
37a This work has narrowed the problem down to the fact that airplane engines should be shielded when built.

Various other methods have been tried & suggested
No further work desirable on any of these ?

E-22
38 - The recorder which I have developed, in my judgement, is the solution of the visual indicator project, as the relay may be made to operate any visual mechanism desired. Draw up a plan, on paper, immediately showing details of a complete system with a visual indicator, the best arrangement you can devise for actual use in an airplane. In addition [illegible] and try out in the laboratory, stating reasons.

E-23 39 This is a problem requiring plenty of original ideas & thoughts. Small may be of help in making some suggestions.

E-24 I think this problem has been solved in so far as the transmission end is concerned. It is held up pending the construction of a shielded ignition system engine, so that a coil may be used on the plane, which will does not give the undesirable uni-directional effect which exists in the equi-signal zone.

E-24

40 - ~~Is it all finished~~

Is our work in this finished? Wouldn't an excellent addition be to develop visual indicating device to replace ~~the~~ of plane? Could not you easily arrange, with your recorder, to have one lamp light when airplane gets off of line to the left and another lamp when off to the right?

PLAINTIFF'S EXHIBIT No. 63—Continued

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

ADDRESS REPLY TO BUREAU OF STANDARDS

E-25
no ~~FF~~ much of the general work of the laboratory can be considered as being done for this project. Some of work for example, all of which is of use indirectly to the air service. Any particular line in mind, between now and June 30?

E-26.
The program of my work prepared by L E W gives an outline of what I am working on. Further tests on audio tuning are being made in connection with increasing the recorder selectivity.

A report on the recorder is being sent to Vaughn, with a suggestion of a method of selective control by radio. Work on this latter idea is pending his reply.

As mentioned above, plans and construction of apparatus for applying the recorder to Problems E-25 ~~FF~~ and E-24 40 might well go forward during winter

F W D

Please return these papers to me with comments
(P.S., retain this paper, keep "Electrical Guided Missiles" until further info - up to date, keep the typewritten L E W report permanently if you want it.)

J H D

PLAINTIFF'S EXHIBIT No. 64

(May be published only after special permission by the Bureau of Standards)

FWD:MP-MWB

RADIO LABORATORY,
BUREAU OF STANDARDS,
November 19, 1923.

A RELAY FOR AUDIO-FREQUENCY CURRENTS, TYPE B

Specifications

This relay is a device whereby the audio-frequency output of any suitable radio receiving set is caused to operate an ordinary telegraph relay. The accompanying prints radio No. 908 (A and B) give the details for the construction of this relay. A complete description of this relay may be found in the following publications: Journal of the American Institute of Electrical Engineers, April, 1922, vol. 41, pp. 310–313; and Electrical World, Dec. 2, 1922, vol. 80, pp. 1222–1223.

1. Materials.—The materials used shall conform in all respects to the requirements of these specifications and the accompanying drawings. Only first-class materials of the kinds specified shall be used. All parts must be free from defects.

2. Workmanship.—The workmanship must be careful and accurate and equal to that required in the manufacture of first-class grades of radio apparatus. All switches and rheostats should be mounted to work freely. The wiring should conform to the best standard practice.

3. Drawings.—It is intended that the accompanying drawings shall show all the details necessary for the proper construction of the relay. No deviations should be made therefrom, except as may be necessitated by the use of parts of greater dimensions, in which case over-all dimensional changes may be made.

4. Panel.—The panel (No. 1) should be made from a good grade of phenolic insulating material. The drilling should be accurately done so that all apparatus mounted on the panel will have proper clearance. The engraving should be neatly done and as indicated.

5. Telegraph relay.—The relay (No. 5) should be of first-class construction. It should have a spring tension adjustment on the armature and an adjustment for moving the cores with respect to the

PLAINTIFF'S EXHIBIT No. 64—Continued

armature. Each magnet spool should be of sufficient size to hold 10,000 turns of No. 38 B. & S. gauge single silk and enamel covered copper wire. A spool 2 inches long by 1⅛ inches in diameter is of sufficient size.

6. Filament rheostats.—The rheostats (Nos. 20 and 21) should be of the best construction. No. 20 should be constructed to pass one ampere continuously without overheating, and should be fitted with a vernier adjustment. No. 21 should be designed to pass two amperes continuously.

7. Paper condensers.—The condensers (Nos. 24, 25, and 32) should be of reliable make and tested to withstand a voltage of 500 DC volts for a period of at least five minutes.

8. Power transformer.—This transformer (No. 19) should be built according to the best practise in transformer construction, proper insulation being used throughout. The core should be constructed as indicated. The number of turns as designated should be properly wound on this core after covering the core with one or two layers of varnished cambric.

9. Audio-frequency tuning condenser.—This condenser (No. 30) should be constructed in accordance with the drawing. The leads should be firmly taped to the condenser proper after completion.

10. Audio-frequency transformer.—This transformer (No. 23) should be of reliable make and equal in quality to the best type manufactured.

11. Electron tubes.—The tubes used are ordinary receiving tubes of reliable make. The tubes should be designed to withstand a plate voltage of 300.

12. The tube sockets (No. 15), telephone jacks (Nos. 13 and 14), power plug and socket (No. 16), buzzer (No. 18), switches (Nos. 6 and 7), leak resistance (No. 17), and binding posts should all be of best workmanship and adapted to the specific use. The two jacks, Nos. 13 and 14, may be of similar make or of different types to accommodate two different designs of telephone plugs. They should be provided with a short-circuiting contact to close the circuit when the plug is out.

13. The staps and supports (Nos. 22A, 22B, 22C, 27, 28, 29, and 31) should be suitably constructed to hold each part firmly in position under all conditions.

14. Cabinet.—The cabinet (No. 4) should be firmly constructed of any suitable wood and neatly finished with any suitable stain and the whole protected with a good varnish.

FOLDOUT(S) IS/ARE TOO LARGE TO BE FILMED

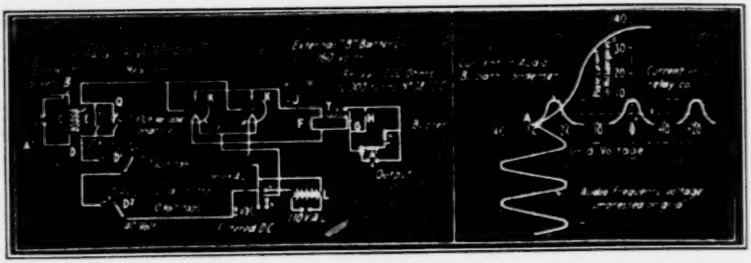


FIGURE 1.—Relay recorder connections for use with batteries and tube characteristics, showing principle of operation

In the wiring diagram at the left *A* is a telephone plug for connecting the relay device to the amplifier output. *B* is a telephone socket to permit operator to listen to the received signal. *C* is an audio transformer of the type used in audio amplifiers, the type used at present being a Signal Corps type C–21. *E* is a 2-megohm grid leak. *Q* is a 0.0006-mfd. variable condenser or a 0.0003-mfd. fixed condenser. *D* is a 20-volt "C" battery connected in series with D^1 a "C" battery variable in steps of approximately 3 volts, and D^2, which is variable in steps of 10 volts. *J* is a 160-volt dry "B" battery. *K* is a type UV–201 radiatron. *F* and *H* are 1-mfd. paper condensers. *A'* is the output to be connected to the apparatus to be controlled. *L* is a step-down transformer for operating the tube filaments from 110-volt alternating-current supply when such is available.

The principle of operation is illustrated at the right. By means of the variable "C" battery the grid voltage is adjusted to approximately 30 volts, at which value the plate current is zero, as shown at *A*. The incoming audio-frequency voltage impressed on the grid varies the grid potential, for example, between the values of −20 and −40 volts. The 10 volts decrease from −30 to −20 causes an increase, for example, from zero to 10 milliamperes, while the increase from −30 to −40 volts is not effective in causing a plate current to flow owing to the fact that −30 volts is already sufficient to reduce the plate current to zero. The result will be a pulsating direct current of 10 milliamperes, maximum amplitude, in the plate circuit. This current, flowing through the plate circuit and condenser *F*, causes an increase in the plate current at the keying frequency. This change, passing through the relay coil, will pull the relay armature over, making contact at *T*, which contact may control any mechanism desired. With the "C" battery grid voltage adjusted for maximum sensitivity it was found that static induction, etc., operated the relay. When these disturbances are not so strong as the signal their effect on the relay may be overcome. For example, if the "C" battery is increased to −35 volts, the critical value for maximum sensitivity being −30 volts, the disturbances due to strays, induction, etc., merely reduce the "C" battery voltage to −30, which is not sufficient to cause plate current to flow. However, the signal, being of greater intensity than the induction, reduces the voltage to −25, which causes a plate current of 5 milliamperes. It will be seen, therefore, that no disturbing effects, if of less intensity than the signal, affect the relay.

PLAINTIFF'S EXHIBIT No. 64—Continued

15. Assembly and wiring.—The assembly and wiring should conform to the best practise, all leads being well insulated and as short as possible. All connections should be soldered.

Attached tracings.—Radio No. 908, sheets 1 and 2.

DEPARTMENT OF COMMERCE,
Washington, D. C.

PLAINTIFF'S EXHIBIT No. 65

Electrical World. The consolidation of Electrical World, Electrical Engineer, and American Electrician. Published by McGraw-Hill Company, Inc. W. H. Onken, jr., editor; Harold V. Bozell, editor. Volume 80. New York, Saturday, December 2, 1922. Number 23.

REMOTE CONTROL BY RADIO POSSIBLE

Description of a relay developed by the Bureau of Standards—simplicity and ruggedness important features—delicate adjustments and light spring contacts avoided

The possibility of remote control of apparatus by radio has excited a great deal of comment among central-station engineers, particularly since the work of the Navy in which war vessels have been so controlled and a number of civilian experiments in which automobiles and smaller vehicles have been so handled were announced in the news columns of the daily press. The Bureau of Standards has developed a relay* by means of which radio signals can be received and recorded or used to operate a remote-control mechanism. As an example it would be possible to send and receive a predetermined set of complicated signals arranged to operate a selective mechanism built on something of the same scheme as the automatic telephone selective devices in common use. The signals might be so arranged that accidental reproduction by an outside agency would be a virtual impossibility. The necessary devices to utilize the relay for remote-control purposes have not been developed, but the possibilities involved are apparently great enough to justify serious study on the part of central-station engineers.

The diagram of connections for the relay recorder for use with batteries is shown at the left of Fig. 1, while the principle of operation is illustrated at the right. Variations of the grid potential produced by the incoming signals cause a pulsating direct current in the

* A complete description of this device was published as "A Relay Recorder for Remote Control by Radio," by F. W. Dunmore, Journal A. I. E. E., April, 1922.

PLAINTIFF'S EXHIBIT No. 65—Continued

plate circuit, which, flowing through the condenser across the relay winding, causes an increase in the plate current at the keying frequency. This change in current closes the relay contacts, thereby controlling any mechanism desired.

During the development of this relay it was found that the rectified audio-frequency current in the plate circuit caused the relay armature to chatter rapidly and make a poor contact with the fixed contact point through which the circuit is closed. This was overcome completely, however, by the addition of a 1-mfd. condenser across the relay coils. This serves the purpose of an audio-frequency bypath for the highly inductive winding of the relay, thus greatly decreasing the resistance of the circuit. The change of plate current due to this audio-frequency causes a second change which occurs at the keying frequency. This latter change passes readily through the relay coils and exerts a steady pull on the relay armature.

It was also found that the 0.0006-mfd. variable condenser (fig. 1) across the secondary of the input audio transformer made possible audio tuning, which increased the selectivity considerably. By means of this tuning it was found that European stations could be made to operate the relay while a high-power station here in the United States would fail to operate it, although the high-power station was coming in on approximately the same wave length and slightly stronger. This was made possible by adjusting the heterodyne note of the European station to a frequency different from that of the local station and then tuning the secondary of the audio transformer to that frequency. The 0.0006-mfd. variable condenser may be replaced by a 0.0003-mfd. fixed condenser and the audio tuning accomplished by adjusting the heterodyne note to the resonant frequency. By means of this audio tuning one of three stations transmitting simultaneously has been selected and caused to operate the relay.

By using two relay recorders connected in series across the output terminals of a single radio receiving set two messages sent on practically the same wave length, but of different audio frequencies, have been accurately received simultaneously.

Tests showed that with a signal strength sufficient to reproduce a plate current of 10 milliamperes the relay could be operated at a speed of forty-eight contacts per second, the contact being sufficient to operate a buzzer. With 3 milliamperes in the plate circuit a speed of twenty-seven contacts per second was obtained, and with 1 milliampere a speed of nineteen per second. In each case the relay armature spring tension was adjusted for the best operation.

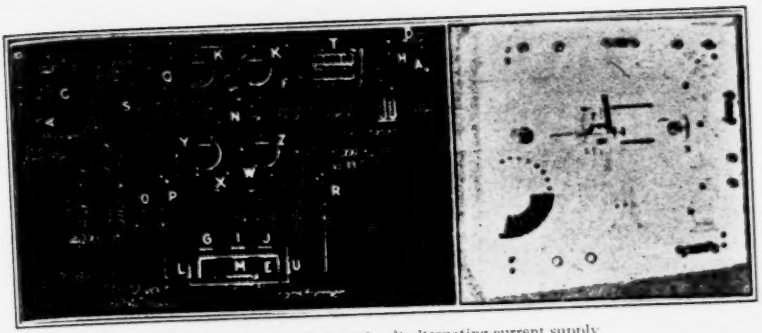


FIGURE 2.—Recorder for 110-volt alternating-current supply

The method of operating the recorder from the alternating current supply consists in the use of two receiving tubes as rectifiers. The tubes *Y* and *Z* are used as half-wave rectifiers, one supplying the plate voltage, and the other the grid voltage, thus eliminating the "B" and "C" batteries. When used as rectifiers, receiving tubes should have the grids and plates electrically connected together. A special transformer *M* with six windings is used. The windings *G* and *J* supply the filaments of the two rectifier tubes, *I* the filaments of the recorder tubes, *U* the high voltage for the plate; *L* supplies the grid voltage, and *E* is the 110-volt primary winding. The rectified alternating current is smoothed out by means of 4-mfd. condensers *P* and *R*, connected across the output terminals. As the currents in the grid and plate circuits are small, smoothing out inductance was unnecessary. It was found necessary to put 40,000 ohms *O* across the output circuit of the rectifier tube supplying the voltage to the grid, as the grid is otherwise insulated from the filament of tubes *K* by the rectifier tube. By means of the filament rheostats *X* and *W* the grid and plate voltages may be varied over any ranges desirable for the most efficient operation of the recorder. By the use of binding posts with straps (as shown at the right) the type *B* recorder may be operated from *A*, *B*, and *C* batteries for supplying the filament, plate, and grid voltages respectively in cases where alternating-current supply is not available.

PLAINTIFF'S EXHIBIT No. 65—Continued

Among the uses to which this apparatus may be applied are: (1) As an ordinary receiver. Here it has advantages over reception with telephone receivers, for one may receive by buzzer or sounder with all induction and interfering noises eliminated, if they are not louder than the signal. (2) A tape or drum-type recorder may be used and a copy made without a trained radio operator. (3) Time signals may be recorded. (4) A call system may be worked by a time switch connected to close the filament circuit for a given time at set calling intervals. (5) Any form of mechanism may be operated by an incoming signal. (6) A receiving station may be located remotely from the transmitting station and the radio signals relayed by wire to the operating room some miles distant. Seven page printers may be operated by radio, the received message appearing in typewritten form as on a typewriter.

For use on a 60-cycle 110-volt supply the recorder is similar in construction to the one described above except that the plate and grid voltages (B and C battery) are supplied from the alternating-current source. As shown in Fig. 2, the current for operating the tube filaments is also obtained from this source so that the recorder is entirely independent of any form of batteries. It is only necessary, therefore, to connect to the 110-volt alternating-current line and the recorder is ready to operate.

In cases where very high-speed operation is desired the ordinary relay may be replaced by one that has been designed for high-speed operation.

F. W. DUNMORE,
Associate Physicist.

RADIO LABORATORY, BUREAU OF STANDARDS,
Washington, D. C.

PLAINTIFF'S EXHIBIT No. 66

Letter No. 26254.

MANUFACTURERS' & INVENTORS' ELECTRIC CO.,
No. 29 and 31 Gold Street, New York, Sept. 30, 1922.

BUREAU OF STANDARDS,
Washington, D. C.

GENTLEMEN: A prospective client desires that we build for him what he describes as "A relay recorder for remote control by radio," and of which, he states, your department would provide information for those interested.

PLAINTIFF'S EXHIBIT No. 66—Continued

His interest in the device is described by the following extract from his letter: "I am not at all concerned with it commercially, and simply want to try it out as an interesting scientific experiment."

Will you kindly advise us—

First: Whether there are any legal obstacles to producing a set of the apparatus for the purpose cited; if not,

Second: Send us such pamphlets, bulletins, or other data as would enable us to lay out and produce the set.

We are inclosing a stamped self-addressed envelope for reply and trust we may hear from you promptly, as our correspondent is anxious for an immediate report from us.

Very truly yours,

MANUFACTURERS' & INVENTORS' ELECTRIC CO.

/s/ A. H. SMITH, *Manager.*

PLAINTIFF'S EXHIBIT No. 66—Continued

Plaintiffs' Exhibit No. 66
C O [illegible] Clerk

Letter No.86354

MANUFACTURERS' & INVENTORS' ELECTRIC CO.

No.29 and 31 Gold Street

New York, Sept. 30, 1922

Bureau of Standards,

Washington, D.C.

Gentlemen:

A prospective client desires that we build for him what he describes as "A Relay Recorder for Remote Control by Radio" and of which, he states, your department would provide information for those interested.

His interest in the device is described by the following extract from his letter "I am not at all concerned with it commercially, and simply want to try it out as an interesting scientific experiment."

Will you kindly advise us

First: Whether there are any legal obstacles to producing a set of the apparatus for the purpose cited, if not,

Second: Send us such pamphlets, bulletins or other data as would enable us to layout and produce the set.

We are inclosing a stamped self addressed envelope for reply and trust we may hear from you promptly, as our correspondent is anxious for an immediate report from us.

Very truly yours,

MANUFACTURERS' & INVENTORS' ELECTRIC CO.,

MES.S

/s/ A.H.Smith, Manager

TRUE COPY
10/6/32

75261—31——27

PLAINTIFF'S EXHIBIT No. 66

Act of '21

manufacturers & Inventors Electric Co
(Attn. Mr. A. H. Smith manager)
New York N.Y.

Subject: Relay records.

Gentlemen:

We have received your letter of Sept 30, '22 no 26254 in which you ask for details regarding the construction of the relay records as developed by this Bureau.

We wish to advise that an unfortunate situation has arisen in connection with this relay in that the Bureau member who developed it, applied for Letters Patent on same, against the policy of this Bureau.

We regret to advise therefore that the construction & use of this relay is subject to the conditions of a patent which has been applied for, but not issued

A description of this relay was published in the Journal of the Institute of Electrical Engineers Vol 61, p 210 April 1922.

We have prepared [illegible] relay and will send you a [illegible] week or two.

Respectfully,

PLAINTIFF'S EXHIBIT No. 67

Model of alternating current amplifier (made physical exhibit by stipulation)

PLAINTIFF'S EXHIBIT No. 67-A

Model of rectifier unit (made physical exhibit by stipulation)

PLAINTIFF'S EXHIBIT No. 68

Model of type B relay (made physical exhibit by stipulation)

PLAINTIFF'S EXHIBIT B FOR IDENTIFICATION

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
Form 304

JOB REQUISITION

JOB No. 10,842

Required by Dr. I-6
Room 202 Bldg. Radio
Approved:

Bureau
Superintendent of Plant
K Chief Mechanician Radio
Woodworker
Glass blower
Optician
Draftsman
Photographer

Requested 10-26-21.
Required
Completed

Purpose Industrial Research Project 42

SPECIFICATIONS JLP:FWD:AN

State briefly if work is to be of temporary or of permanent construction, accuracy and finish required, or such points which are of importance. Accompany requisition with sketch or drawing. Use separate paper for sketch.

Cut, drill and engrave one bakelite panel for radio recorder.

ESTIMATE

Time $
Material $
Total

Signed

Chief of Shop

Estimate must be obtained in advance from chief of shop before obtaining the approval of the Director

PLAINTIFFS' EXHIBIT D FOR IDENTIFICATION

Final hearing
November 22, 1929.

In the United States Patent Office

Patent Interference No. 53154

PUPIN v. DUNCAN v. LOWELL AND DUNMORE v. BLATTERMAN

RADIO RECEIVING APPARATUS

Application of Michael I. Pupin filed February 4, 1924, No. 690586.

Application of Robert D. Duncan, jr., filed October 20, 1923, No. 669662.

Patent granted Percival D. Lowell and Francis W. Dunmore, May 15, 1923, No. 1455141, on an application filed March 27, 1922, No. 547111.

Application of Albert S. Blatterman filed March 10, 1922, No. 542525.

Mr. Wesley G. Carr for Pupin.

Mr. William E. Beatty and Mr. I. R. Goshaw for Duncan, jr.

Mr. John B. Brady and Mr. John Boyle, jr., for Lowell and Dunmore.

Mr. David P. Wolhaupter for Blatterman.

The subject matter here in controversy relates to the elimination of hum in a receiving set employing thermionic tubes having energy supplied thereto from an alternating current source. It is to be noted that the count is stated rather broadly in some respects. There were two counts in the instant interference at the time it was before the law examiner. He stated (paper No. 48, page 3):

"The counts are not limited to radio telephony, nor to a source of alternating current of low frequency, nor to a source of alternating current for supplying heating current to the tube filaments as well as current for the plate-filament circuits."

It is specific in that it calls for—

"means connected to said amplifying and rectifying means for eliminating the hum of said alternating current in said apparatus."

The single count in issue reads as follows:

"In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said signals, means for rectifying said signals, a source of alternating current for supplying power to said amplifying means, and means connected to said amplifying and rectifying means for eliminating the hum of said alternating current in said apparatus."

Pupin did not take priority testimony but relies on his patent No. 1571458, filed December 31, 1915. The other three parties herein involved took testimony. The parties Pupin and Duncan, being involved here on applications filed after the issuance of the Lowell and Dunmore patent, have the burden of proving their case beyond a reasonable doubt. (Hoffman v. Outman, 20 F (2d) 280; 57 App. D. C. 264; 365 O. G. 478; 1927 C. D. 197.)

The case of the junior-most party, Pupin, will be considered first. As previously stated, Pupin relies upon his patent 1571458. In the patent application as originally filed reference is made to wireless systems in four different paragraphs but the paragraphs are substantially identical. The paragraph near the top of page 5, which is probably as comprehensible as any, reads:

"A machine like that shown in the drawing, having two commutators and two associated pilot conductors, is well adapted to replace both of the batteries which are used to-day for heating the filaments and for exciting the vacuum-tube relays and amplifiers in wireless wave transmission systems."

At the top of page 6 it is stated that the commutator machine may be replaced by a source of alternating current and a rectifier. The

original claims do not contain any reference to a wireless transmission system.

Before the issuance of his patent Pupin copied two claims from the Lowell and Dunmore patent, herein involved, and asked for an interference. In a memorandum, paper No. 26½, the primary examiner stated:

"But the proposed claims require in addition, that the combination be in an apparatus for *receiving* radio signals and that it comprises a means for rectifying the signal energy.

"It is not believed that the broad statements are sufficient to establish the fact that the applicant invented the combination in the specific arrangement for a wireless receiving system shown by Schloemilch of his particular means for supplying the filament or exciting current of the amplifier. Moreover, whatever the disclosure may cover, the subject matter of the proposed claim is not within the original statement of invention and oath."

The petition for an interference in due course was denied.

Meantime Pupin filed a so-called divisional application, which is here involved, and transferred the Lowell and Dunmore claims from the earlier application to the newly filed one which is directed to a radio receiving apparatus. In the first office action the primary examiner required him to change "division" to *continuation in part*, and he further stated:

"Claims 1 to 3 read on Fig. 1 of the present application, but, as pointed out above, the subject matter of this figure was not disclosed in the parent case; therefore, for these claims, applicant is entitled only to the date of filing of the present case. Before he may have an interference with the patentees, Lowell et al, on these claims, he must show that the claims are allowable to him and must also file an affidavit as required by Rule 94. These claims are not allowable to this applicant unless he is able to overcome the patent to Farrington, cited (which is not a reference as against the patentees) by affidavit under Rule 75. The claims are rejected on Fig. 3 of Farrington, the application of which to the claims appears to be obvious."

Pupin traversed the action of the examiner. Thereupon the examiner gave Pupin the option of either appealing to the examiners-in-chief or filing affidavits under Rules 75 and 94. Pupin chose the latter method for the purpose of securing an interference.

During his time for taking testimony in chief Pupin called two witnesses to show the state of the art, and one of them was asked to define the term "wireless wave transmission systems" as used at the time his (Pupin's) application was filed.

After a careful consideration of the arguments advanced by Pupin it does not appear in a satisfactory way that he contemplated using the device disclosed in his patent in a manner set forth in the count.

If, after reading the patent, an electrical expert did construct a device as defined in the count, it would be merely accidental. It would not result from any preconception nor from anything specifically directed by the patent for organizing the device. Pupin is presumed to have invented the device disclosed by the natural import of the words used in describing the invention, and not a device that some one might construct by applying certain limited meanings to the words of the patent. Pupin filed his earlier application more than six years before any of the other parties of the instant interference filed theirs. He never made claim for the subject matter in issue until the issuance of the Lowell and Dunmore patent nor attempted, as far as shown, to construct a device in accordance therewith. He can not be said to have invented that for which he has given no specific directions for construction. Pupin has the burden of proving his case beyond a reasonable doubt. It is the opinion of this tribunal that the earlier application of Pupin does not teach or even suggest the invention contemplated by the issue of this interference and it is so held.

In the quoted paragraph from his application reference is made to "both storage batteries." Pupin urges that transmission systems had only one storage battery and therefore he must have referred to a receiving system which had two storage batteries. But at final hearing Duncan called attention to Weagant patent 1384108, which discloses a transmission system in which two storage batteries are used.

In their original preliminary statement Lowell and Dunmore allege conception on October 1, 1921, and a reduction to practice on December 10, 1921. After Pupin had completed his case in chief and the party Duncan had taken some or all of his testimony in chief, counsel for Lowell and Dunmore was led to interpret the count in issue in a different way from the way in which he interpreted it in preparing the original preliminary statement of Lowell and Dunmore. It seems that he was led to entertain this different construction of the count by the testimony put in on behalf of the party Duncan. Promptly, after interpreting the count in this new way, search was made in the available evidence for Lowell and Dunmore and certain items of evidence were found which he believed would support the count. Thereupon he filed a motion for leave to file an amended preliminary statement setting up the earlier dates found. This motion was denied by the examiner of interferences and this holding affirmed by the assistant commissioner. This motion is brought again at this time, but since the assistant commissioner has already made a ruling on this motion it is not an open question here and is dismissed. All dates will be considered as made in their original preliminary statement.

Both Lowell and Dunmore were employed in the Radio Laboratory, Bureau of Standards, during the time their systems considered herein were developed, and were required to file weekly and monthly reports of their work. They first designed a telegraphic relay having two thermionic tubes the filaments of which, by throwing a single-pole switch, could be heated either by direct or alternating current. In his weekly report card for September 26–September 30, 1921, with respect to the telegraphic relay mentioned above on September 28, Dunmore recorded:

"mounted relay on base and put in transformer to operate filament on A. C. worked O. K."

This relay, using a 1605B six-tube amplifier (Exhibit 58) or a French set (Exhibit 59) connected in front of the same (Lowell and Dunmore's rec., top of page 54), was employed at times to operate a recorder. He drew a complete circuit of the relay and recorder on page 41 of his notebook (Exhibit 8) under date of October 7, 1921, on which day the system was operating. (Q. 27.) These dates are substantiated by Lowell. (Q.'s 27, 28, 56, and 58.) The relay later was housed in a cabinet, a picture of the same being offered in evidence as Exhibit 2.

Lowell and Dunmore continued to make improvements on their relay and set out to design a receiving set which would operate from the ordinary 60-cycle house current without any hum being heard in the phones or loudspeaker. On his report card for December 3, 1921, Dunmore recorded in part:

"Worked out circuit to get both grid and plate voltage 60-cycle A. C."

In his notebook (Exhibit 8), page 46, under date of December 8, 1921, he shows a sketch of a rectifying device which he used to obtain plate voltage for his relay from 60-cycle A. C. The memorandum reads as follows:

"Set up this circuit and got in working O. K. Could use it for "B" battery voltage on a 6-tube amplifier. Engle and Lowell listened in with this on the amplifier.

"Also found a one-tube rectifier would work O. K. to give 160 volts for my recorder, same circuit as above, only the 32,000 ohms resistance was not used. This gave 160 volts to 200 volts."

As disclosed on the next page of his notebook he set up on the same day another device suggested by Snow for obtaining "B" battery voltage from an A. C. source. This device comprised a commutator and a fixed condenser. Nothing further is recorded with respect to this device.

The next day, December 9, Dunmore used two tungars for rectifying his A. C. power. On page 49 of his notebook, under date of December 10, 1921, he shows a sketch of a receiving set in which

energy was supplied both to the filament and the plate from an A. C. source. Evidently this arrangement was tested out on that day for the following note appears below the sketch:

"Tried the above only used 1 detector and 2 stages audio. It worked but was insensitive. Got most of hum out."

This set was continuously improved until by January 20, 1922, the final circuit for a complete A. C. radio receiver for telephonic signals was worked out. The testimony of Lowell (Q.'s 40, 41, 60, 64, 78, and 79) is in full accord with that of Dunmore.

Buckley, a mechanical draftsman who made several drawings both for Dunmore and for Lowell, corroborates (Q. 4) Dunmore to the extent that the latter was working on a scheme to operate the filaments of the tubes in the relay on alternating current at least as early as September 28, 1921. In answer to Q. 34 Kruse states in part:

"The device of Exhibit No. 2 was in existence before Dunmore and I went to Atlantic City in November of 1921, on about the 6th (the date is right within 24 hours) on a job for the Coast Guard, and the device had been preceded by rough models still before which some of this rectifier work was going on. * * *."

Other witnesses testify to substantially the same effect.

Engel, who is employed by the Radio Corporation of America at the present time, recalls seeing a receiving set in which the filament, grid, and plate voltages were obtained from a A. C. source, and another plate-supply device comprising "a large condenser which was charged periodically by an interrupting device which charged the condenser at intervals, the current stored in the condenser being supplied to the set." (Q. 64.) Engel is one of the individuals referred to in the above-quoted memorandum of Dunmore for December 8, 1921. He testifies (Q. 65) that he does "not recall vividly the particular demonstration mentioned."

The testimony of Lowell and of Dunmore is further corroborated, with respect to the dates when they developed the plate supply from an A. C. source for their relay and the introduction of this type of plate supply into a receiving set, by Buckley and Ould. Buckley testifies that he made a drawing of the A. C. relay some time in January of 1922, which was after this device had been proven successful. About the same time, after having heard signals, such as music and speech, he made a drawing of the receiver which operated entirely from an A. C. source. Ould fixes the time more definitely. He testified (Q. 41) that he saw the experimental set up of the radio receiving set suitable for reception of radio telephony, where the set had alternating-current supply for the tubes, about a week before he went on his vacation, which was December 23, 1921, and that radio telephony was successfully received at that time.

The development of the Lowell and Dunmore device is recorded on the time reports and in the notebook of Dunmore. There is ample proof that time cards were made out at the Bureau of Standards on the date indicated or very closely thereto. Several witnesses saw Dunmore making records of tests approximately at the time they were conducted.

Inasmuch as the dates given by Lowell and Dunmore are not attacked by the other parties to this interference, it is necessary to consider only the sufficiency of the proofs to satisfy the demands of the count which is rather broad as stated at the beginning of the decision. Some of the counts in the companion interferences include two types of rectifying means, namely, one for rectifying the radio signals, or detector, and one for rectifying the low-frequency alternating current which constitutes the source of power. In the count under consideration the only rectifying means referred to is a detector.

Simply mounting a relay on a base and putting in a transformer for operating the filament on alternating current, as was done by Lowell and Dunmore on September 28, 1921, is not sufficient to show that any means was connected with the detector (rectifying means) for eliminating hum.

With respect to their apparatus tested on October 7, 1921, and partially shown on page 41 of Exhibit 8, Lowell and Dunmore point out on page 26 of their brief that the detector of either Exhibit 58 or 59 was the rectifying means, and that the tuned input system, the tapped battery in the grid circuits and the condenser in shunt with the relay coils constituted the means connected to the amplifying and rectifying means for eliminating the hum. It does not appear from the proofs that alternating current was applied to any part of either Exhibit 58 or 59 during this test; consequently, even if the detector of either of these exhibits is the rectifying means of the count there would be no necessity in connecting hum eliminating means to the detector when there was no hum in this portion of the circuit. The count is not applicable to this apparatus.

Lowell and Dunmore's scheme for obtaining grid and plate voltage from an A. C. source as worked out on December 3, 1921, does not necessarily include means connected to the detector for eliminating the A. C. hum. This scheme, therefore, is not sufficient to establish conception.

The amplifier tested on December 8, 1921, page 46 of Exhibit 8, evidently was a 1605B amplifier because reference is also made to the A. C. relay. In answer to Q. 61 Lowell also stated that the amplifier tested on that day was of this type. See also Lowell and Dunmore's record, top of page 58. This amplifier comprised three stages of radio frequency amplification, detector, and two stages of

audio frequency amplification. The "B" battery voltage was supplied from an A. C. source and the device worked satisfactorily. Clearly this is sufficient to establish conception. Inasmuch as the 1605B amplifier was constructed for receiving I. C. W. signals (Lowell and Dunmore record, p. 72, Q. 31) it was capable, also, of receiving telephonic signals. The date of conception, therefore, of Lowell and Dunmore is December 8, 1921, whether the count be construed to include both telephonic and telegraphic signals as stated at the beginning, or construed to include any telephonic signals as contended by Duncan and by Blatterman.

Lowell and Dunmore continued to improve their device and the same was reduced to practice not later than January 20, 1922. The exact date of reduction to practice is inconsequential in the instant interference.

Blatterman directly and Duncan indirectly charge that the developments on radio reception up to about January 20, 1922, by Lowell and Dunmore were the sole work of Dunmore. After a perusal of Lowell and Dunmore's proofs this tribunal has not found sufficient evidence to warrant holding that the work on the A. C. relay and the A. C. receiving set during the time in question was not participated in both by Lowell and by Dunmore.

Duncan's case will now be considered. In the early part of 1921 he was stationed at the Office of Chief Signal Officer and at the Signal Corps Laboratories, Bureau of Standards. From July, 1921, until July, 1922, Duncan was chief engineer of the Signal Corps Radio Laboratory, Bureau of Standards. From time to time he filed reports with respect to his work with the Office of the Chief Signal Officer.

In his preliminary statement Duncan alleges that he conceived the invention and reduced it to practice on or about the 1st of April, 1921. In support of this he testifies (Q. 57) that he first examined the behavior of a single tube whose filament was lighted from alternating current, and then he turned his attention to a type SCR–72 two-stage audio-frequency amplifier, which was revamped to permit the filaments of the tubes to be lighted in the same manner as the filament of the single tube. No sketch of the hookup of the revamped amplifier was made at the time of the test, but the original revamped amplifier is still at the Signal Corps Laboratory, Bureau of Standards. (Q. 69.) In his report with respect to these tests he stated (paragraph 4 of Exhibit 3):

"A few experiments were conducted with a view to operating the filaments of receiving tubes from alternating current. So far no entirely satisfactory results have been obtained, but a method has been worked out which it is believed with proper development will entirely eliminate the presence of the 60-cycle ripple in the telephone receivers."

No further work was done along this line until May, 1923.

The testimony of Mauborgne is entitled to very little weight. He stated (Q. 20) that he was not familiar with the details of Duncan's work with regard to which he was testifying. Lowell and Dunmore call attention to the fact that in answer to Q. 24 Mauborgne said in part:

"* * * Mr. Duncan had verbally reported to me that he had done some very successful work in the production of receiving apparatus involving the use of alternating current on both the filaments and the plates of the receiving tubes,"

and that Duncan did not attempt to use alternating current on the plates of receiving tubes. Furthermore, Mauborgne failed to describe the receiving apparatus which he alleges Duncan produced.

Isler, Duncan's assistant, describes the revamped SCR–72 amplifier and corroborates Duncan with respect to the tests made by the latter, but he is unable to fix any dates except by those on the exhibits. Isler was not asked to draw a sketch of the revamped amplifier, but was shown a sketch (Exhibit 15) which was drawn by Duncan while on the stand. Isler identified this sketch.

Since there is no attack made on sketches Exhibits 13 and 15 they apparently illustrate the hookups of the two systems tested by Duncan. Obviously the system illustrated in Exhibit 13, which does not have an amplifying means in addition to the rectifying means, does not support the count. In Exhibit 15 the alternating current is applied to the filaments only of the audio amplifying tubes. A signal, in traversing the set, passes first through the detector, then the audio amplifier, and finally the reproducer (headset). Signals or undesirable noises would not pass in this apparatus from the audio amplifier to the detector to any appreciable extent. For this reason there is no necessity for a hum-eliminating means being connected with the detector as called for by the count, and there is none shown, nor any pointed out by Duncan on page 31 of his brief in applying the count in issue to his device.

Since the count is not applicable to either system relied upon by Duncan and he did no further work on the invention until the early part of 1923, which is subsequent to the dates accorded to Lowell and Dunmore, it is held that he is not the first inventor of the subject matter in issue.

Blatterman is senior party in this interference. At the time he was experimenting with radio-receiving sets of the nature involved herein, he was employed in the Signal Corps at Camp Alfred Vail, now called Fort Monmouth, N. J. He was especially engaged in the design and development of radio-frequency amplifiers. About this time public broadcasting was just being initiated. He noted that the Government was equipped with very good receivers but the only

receiving sets, that he was aware of being sold to the public, comprised a detector and two stages of audio-frequency amplification. These sets were relatively insensitive as regards long-distance reception. (Q. 10.) He conceived the idea of constructing a sensitive radio-frequency amplifier to be connected in front of the sets then on the market. With this in mind he first developed a radio-frequency transformer for the amplifier, which transformer was completed early in November, 1921. It occurred to him that it might be difficult to sell an amplifier if it derived its energy from batteries; consequently, he, being aware of the fact that transmitters had been energized from an A. C. source, decided to develop a radio-frequency amplifier which would operate from such a source.

He testifies that on November 22, 1921, he formed a partnership to exploit his radio-frequency transformer and on the following Saturday, November 26, 1921, he conceived the invention in issue. Camp Vail was closed on Sunday; as a consequence, he had to wait until Monday, November 28, 1921, before he could test out his scheme. He went out to the camp the first thing on Monday morning. He and his assistant Harris took a standard SCR–122 Signal Corps receiver, which employed four stages of radio-frequency amplification, a detector, and two stages of audio-frequency amplification, cut off all the wires which connected the radio-frequency portion of the circuit to the detector and audio portion, and cut off all the wires which connected the radio-frequency portion of the circuit to the detector and audio portion, and cut off the fourth stage of radio-frequency amplification, including the tube socket and transformer, from the balance of the circuit. Blatterman made a small step-down transformer for supplying all of the power to the radio-frequency amplifier portion of the circuit. A vacuum tube was inserted in the isolated fourth tube socket and used as a rectifier for supplying rectified A. C. voltage to the plates of the three remaining radio-frequency tubes. The grid and plate return leads were connected to the movable arm of the potentiometer which was already in the set. The filaments of the three radio-frequency tubes were energized by low voltage alternating current. All of the changes were made and the new arrangement put into final operating condition and tested during the morning of November 28, 1921. (Q. 22.) Blatterman went directly into the office after the test (Q. 41) and under the same date drew a sketch and wrote a description in one of his notebooks of his modified SCR–122 receiving set, which disclosure was witnessed by Harris.

In the early part of December, 1921, Blatterman testifies he began the manufacture of commercial sets. The circuit in his first com-

mercial sets was the same as the circuit of his device alleged to have been tested on November 28, 1921. (Q. 83.) During the early part of 1922 he developed and marketed a battery-operated set. (Q. 101.) He filed his application involved herein on March 10, 1922.

Harris is the sole corroborating witness with respect to Blatterman's test on November 28, 1921. He testifies (X Q.'s 76, 77) that he can not fix the date from memory and that there are no circumstances by which he can fix it as to the exact day. When Harris witnessed the disclosure prepared by Blatterman he did not date it November 28, 1921, but wrote, "This test was made on or about November 28, 1921."

During the motion period Lowell and Dunmore brought a motion to dissolve on the ground that the disclosure in the Blatterman application involved herein is not sufficient to permit him to make the counts then in issue. This motion was denied. No testimony was taken relative to the disclosure in question; as a consequence, this question may not be considered at this time (Rule 130).

Blatterman's proofs will now be considered. In the sketch of the reconstructed SCR–122 receiving set the grid and plate return circuits are shown connected to the movable arm of a single potentiometer and a condenser connected across the low-frequency power rectifier, respectively. No hum-eliminating means is shown connected to the detector circuit. The detector and audio-frequency amplifiers are entirely separated from the remainder of the system except that they are inductively coupled thereto. In the Lowell and Dunmore patent, in which the count originated, a condenser 9–a is shown connected directly to the detector circuit. If the potentiometer and condenser are the "means connected to said amplifying means," they can not be included again as the means connected to the rectifying means.

Blatterman sought only to develop a radio-frequency amplifier and was not concerned in particular about the detector (Q. 10), and it does not appear from his proofs that there was any hum in it to be eliminated. In applying the count to the sketch of the reconstructed SCR–122 receiver on page 105 of his brief it appears that he considered the vacuum tube T to be the rectifying means. The context of the count clearly shows that the detector is the rectifying means. So construed, the apparatus tested by Blatterman does not support the count in issue.

The count being not readable on Blatterman's reconstructed device, and his early commercial sets embodying the same circuit arrangement, he must rely on his filing date, March 10, 1922, for conception and reduction to practice. This date being subsequent to the dates

accorded to Lowell and Dunmore for conception and reduction to practice he is not entitled to the award of priority.

Priority of invention of the subject matter in issue is hereby awarded to Percival D. Lowell and Francis W. Dunmore, a junior party.

Limit of appeal: April 8, 1930.

H. I. HOUSTON,
Examiner of Interferences.

MARCH 19, 1930.

DEFENDANT'S EXHIBIT NO. 1

GENERAL APPOINTMENT

DEPARTMENT OF COMMERCE,
APPOINTMENT DIVISION,
Washington, January 8, 1918.

Mr. F. W. DUNMORE,
Through the Director, Bureau of Standards.

SIR: You have been appointed, subject to taking the oath of office, Laboratory Assistant in the Bureau of Standards at a salary of thirteen hundred and twenty dollars per annum, effective on the date on which you enter upon duty in the above-mentioned position.

Your appointment will continue for a period not to exceed thirty days from the date of receipt of a certification of eligibles for permanently filling the above-mentioned position.

By direction of the Secretary:
Respectfully,

(Signed) CLIFFORD HASTINGS,
Chief of Appointment Division.

Appropriation: Military Research (Signal Corps Radio), Bureau of Standards.

Vice: New position.

Legal residence: Rhode Island.

DEPARTMENT OF COMMERCE

OATH OF OFFICE

I, F. W. Dunmore, do solemnly swear that I will support and defend the Constitution of the United States against all enemies, foreign and domestic; that I will bear true faith and allegiance to the same; that I take this obligation freely, without any mental

DEFENDANT'S EXHIBIT No. 1—Continued

reservation or purpose of evasion; and that I will well and faithfully discharge the duties of the office on which I am about to enter: So help me God.

F. W. DUNMORE.

Sworn to and subscribed before me this 14th day of Jan., A. D. 1918.

H. D. HUBBARD,
Notary Public.

Bureau or office to which assigned: Standards. Position: laboratory assistant. Salary: $1,320 per annum. Where employed: Washington. Date of entrance upon duty: Jan. 14, 1918. Nature of appointment: Temporary. Appropriation to which charged: Military research (Signal Corps—Radio).

The subsequent oaths of office and appointment and promotion certificates are in form similar to the foregoing. There follows in lieu of a reprint of each of the certificates a summary showing the date of appointment, the position to which appointed, the salary, and the appropriation to which this is charged.

Date	Position	Salary	Appropriation to which charged
Mar. 13, 1918	Laboratory assistant	$1,320	Military research. (Signal Corps—radio.)
Oct. 8, 1918	Assistant physicist (By promotion from Laboratory Assistant.)	1,500	Do.
Nov. 17, 1919	Assistant physicist (By promotion from $1,500 per annum.)	1,680	Radio research, Bureau of Standards.
July 1, 1920	Associate physicist (By promotion.)	1,980	Radio research, Bureau of Standards.
Oct. 1, 1920	Associate physicist (By promotion.)	2,100	Industrial research, war radio.
June 1, 1921	Associate physicist	2,400	Industrial research, war radio development.
Mar. 2, 1923	Associate physicist	2,500	Radio research, Bureau of Standards.
May 16, 1923	Physicist (By promotion.)	3,000	Industrial research, Bureau of Standards.
Dec. 1, 1923	Physicist (By promotion.)	3,300	Radio research, Bureau of Standards.
Nov. 8, 1926	Scientist (physicist) (By promotion.)	3,800	Air commerce.
July 1, 1927	Scientist (physicist)	3,800	Aircraft in commerce.
July 1, 1928	Compensation changed to $4,000 under Welch Act.		

DEFENDANT'S EXHIBIT No. 2

Vol. II. July 19, 1921. No. 13. Journal of the Washington Academy of Sciences. Office of publication, 211 Church Street, Easton, Pa.

DEFENDANT'S EXHIBIT No. 2—Continued

RADIOTELEGRAPHY.—A chronographic recorder of radio time signals.[1] **E. A. Eckhardt and J. C. Karcher, Bureau of Standards. (Communicated by S. W. Stratton.)**

The problem of recording radio signals is one of amplifying the feeble energy in the radio signal to such a degree that in the amplified amount it is sufficient to operate a recording device. Whether the recording be done photographically or by means of some form of stylus, the electrical energy of the radio signal at some stage of the process gives rise to a mechanical motion. The aim of the experimenter is to make the chain of events between the receiving antenna and the mechanically moving element, as well as the apparatus embodying it, as simple and reliable as possible. If it is desired to use the recording apparatus in field service these considerations are especially important. Ruggedness then becomes an additional imperative requirement. The recording apparatus described in this paper was intended primarily for field use, since with it the U. S. Coast and Geodetic Survey wishes to record Annapolis time signals at any field station which it may desire to occupy within the borders of the United States.

So far as we know, success in recording radio signals at long range has heretofore been attained only by the use of amplifiers of many stages. Despite the great progress which has been made in the design and construction of such devices, a field party, which needs to give considerable attention to the weight of its equipment and which in general is not accompanied by a qualified radio engineer, will not contemplate their use with any degree of confidence. When a multiplicity of electron tubes is used the storage battery equipment presents a serious problem to the field party. Either the battery must be of large capacity or provision must be made for frequent charging. If, therefore, any radio receiver-recorder is to be available for service in the field, keeping the number of tubes down to a minimum is an important consideration.

The nucleus of our receiver-recorder is the regenerative circuit shown in figure 1. It consists of a capacity C_1 and inductance L_1 in the grid circuit of the electron tube, the inductance L_1 being coupled to the inductance L_2 in the plate circuit of the tube. In order that the circuit may be regenerative the coupling must be of such sign that a rise in plate current results in a rise in the grid potential. The potentiometer P serves to adjust the mean grid potential over a suitable potential range, both negative and positive.

[1] Presented before the Philosophical Society of Washington, March 26, 1921. Received May 5, 1921.

DEFENDANT'S EXHIBIT No. 2—Continued

Such a circuit is capable of acting as a generator of electrical oscillations. The frequency is determined in the main by the inductance capacity combination L_1 C_1.

If, by adjusting the potentiometer P, the grid potential is gradually made more and more negative, the oscillations are stopped. Upon gradually raising the potential it will be found that there is a critical grid potential at which the oscillations set in. This grid potential is characteristic for the circuit used.

Figure 2 shows a plate current-grid potential, characteristic of a typical receiver type electron tube. If the grid be at a mean potential corresponding to the point C_γ and an alternating e. m. f. be applied to it, the increase of plate current during the positive half of

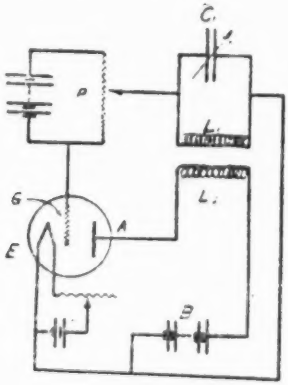


FIG. 1.—Regenerative circuit

the cycle will be greater than the decrease during the negative half. This is due to the curvature of the characteristic. Thus the mean value of the plate current is increased by the periodic e. m. f. on the grid. If C_γ is the critical point on the characteristic at which the circuit becomes self-oscillatory, the amplitude of the periodic component of the grid potential builds up; likewise the amplitude of the periodic plate current, and there results a rise in the mean plate current as shown by Figure 2. By proper design, conditions may be so chosen that the rise in plate current occasioned by the initiation of oscillations in the regenerative circuit is many times the plate current flowing just before the oscillations set in. Regenerative circuits have been operated by us in which the plate current shoots up from 2 or 3 milliamperes to 50 milliamperes when by raising the grid potential a small fraction of a volt the circuit is made to pass from the non-oscillatory to the oscillatory state. In our recorder

DEFENDANT'S EXHIBIT No. 2—Continued

the rise is from approximately ¼ milliampere in the non-oscillatory to 2 milliamperes in the oscillatory state.

The rise in mean plate current which accompanies the starting of the oscillations is an important feature from the point of view of recording radio signals. An ordinary telegraph relay which will operate on one or two milliamperes may be introduced into the plate circuit. The starting of the oscillations will cause the relay to function and the relay contact may be used either to open or close a local

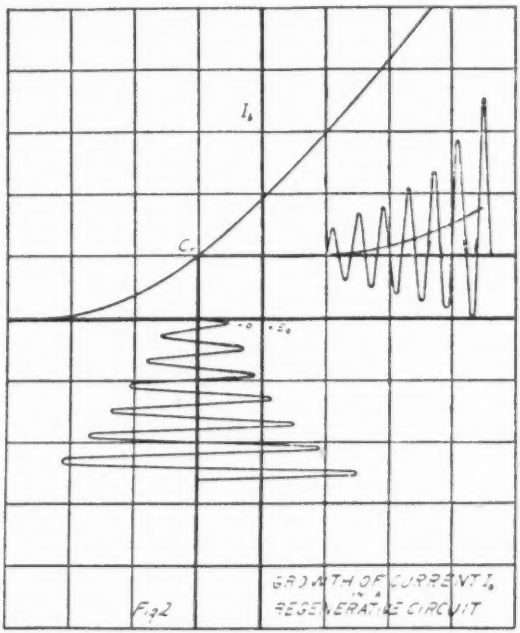


FIG. 2.—Growth of current in a regenerative circuit

circuit. If the local circuit is one operating a chronographic pen the starting of the oscillations may be chronographically recorded.

Now the change in grid potential necessary to pass from the nonoscillatory to the oscillatory state is very small, so small indeed that it may be provided by a radio signal received on an antenna suitably connected to the grid of the electron tube of the regenerative circuit. Figure 3 shows a suitable arrangement for this purpose. The antenna leads to the tuned circuit which is connected to the grid of the tube through the potentiometer. The inductance of this tuned circuit is coupled regeneratively with an inductance in

DEFENDANT'S EXHIBIT No. 2—Continued

the plate circuit. The function of the intervening coil we shall consider presently. The oscillations due to the incoming radio signal cause the grid potential to vary periodically about its mean value. If this mean value is just below the critical one peculiar to the regenerative circuit the incoming signal will cause the critical value to be reached, and local oscillations will be initiated. Unfortunately, however, the local oscillations persist even after the mean grid potential has been restored to its original value below the critical one. To stop these oscillations by changing the grid potential it would have to be lowered considerably below the critical value. We are, therefore, thus far possessed of the means for set-

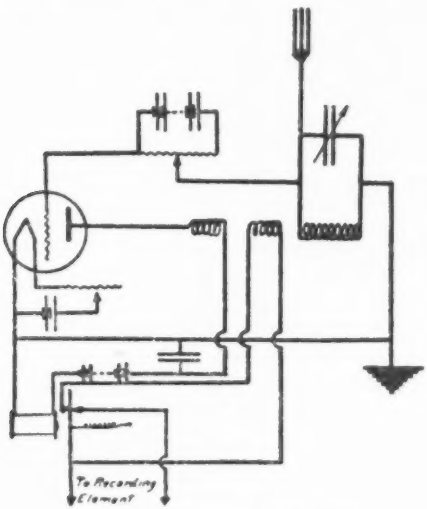


FIG. 3.—Radio recording receiver

ting up local oscillations by the incoming signal, but the instrument does not automatically reset itself.

Means must be provided for killing the local oscillations as soon as the periodic potential variation of the grid has ceased, i. e., when no signal is being received. For this purpose the telegraph relay in the plate circuit is provided with a second contact, insulated from the first, which is closed when the relay armature is attracted by the relay magnet. The closing of this rear contact short-circuits a low resistance coil of a few turns mounted between the regenerating coils. When short-circuited, this coil provides an effective screen between the grid and plate inductances and regeneration is promptly stopped. The stopping of the local oscillations occasions a decrease

DEFENDANT'S EXHIBIT No. 2—Continued

in the plate current, the relay armature is released, and the oscillation-stopping contact is opened. If the potential oscillations of the grid still persist as the armature is leaving the rear contact the local oscillations will immediately build up, the mean plate current will rise, and the relay armature will be attracted to the relay magnet before it gets far enough away to make the outer, pen-controlling, contact. Thus, during a long dash signal the relay armature simply

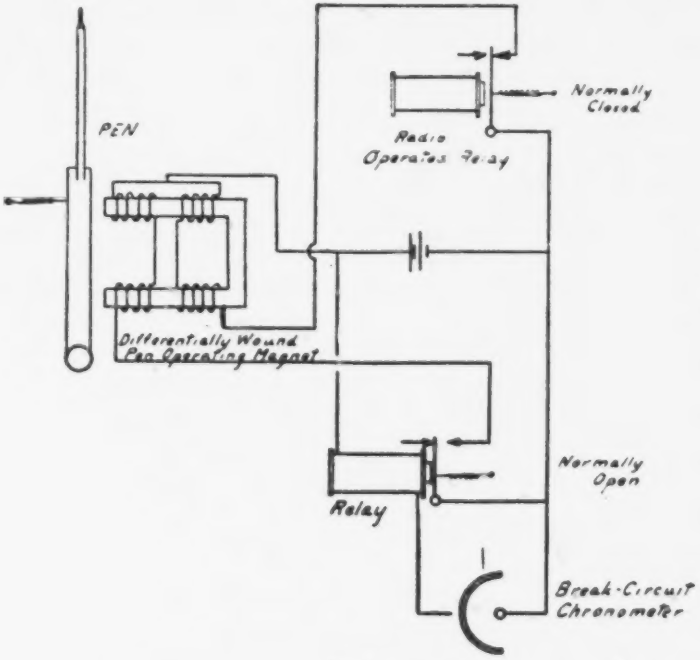


FIG. 4

chatters against the rear contact, without at any time moving far enough to make the outer one. It is clear, therefore, that during the arrival of the signal the relay armature is chattering against the rear contact and between signals it rests against the front one.

Figure 4 shows the front contact of the telegraph relay normally held closed by the tension spring. The starting of local oscillations causes the relay to operate in the manner previously described, the front contact opens and the rear one closes. The opening of the front contact operates the chronograph pen, and the closing of the rear one short circuits the oscillation-choking coil. The making of

DEFENDANT'S EXHIBIT No. 2—Continued

the rear contact, therefore, stops the oscillations, causes the plate current to fall back to the nonoscillatory value, the relay to release, and the front contact to close.

If a continuous dash signal is being received, the local oscillations build up as soon as the relay armature leaves the rear contact, and it is drawn back before the front contact is remade. Thus the chronograph pen continues in the released position until the signal stops long enough for the relay armature to remake the front contact. With no signal coming in, the front contact of the relay is closed and the chronograph magnet is energized. The pen-carrying armature is, therefore, held against the inner stop. When the incoming signal begins, the front contact is opened, the chronograph magnet is deenergized, and the pen-carrying armature is released against the outer stop. It remains against the outer stop until the front contact of the plate circuit relay is again made. The pen then returns to its initial position against the inner stop.

In the recorder design now in use a single stage of radio frequency amplification is provided, so that the signal oscillations may be amplified before being applied to the grid of the tube in the regenerative circuit. This preliminary stage of amplification increases the overall sensitivity somewhat, but the regenerative circuit itself and the manner of its use account for all but a few per cent of the total sensitivity attained.

The preceding account describes a complete mechanism for recording radio signals. A similar recording system has recently been described by Captain L. B. Turner.[2] His methods of stopping the local oscillations involve readjustments in the regenerative circuit when the oscillation-stopping contact is opened. If, for example, the plate inductance is short circuited for the purpose of stopping the local oscillations, the removal of the short involves reestablishment of a difference of potential at the terminals of this coil. This causes a surge which tends to restart the oscillations and results in the recording of a spurious signal. The method employed by us of stopping the oscillations involves no readjustments in the regenerative circuit when the oscillation-destroying contact is opened and the system is restored to the receptive state. We are, therefore, enabled to work very much nearer the critical grid potential with correspondingly enhanced sensitivity.

It is proposed to use the radio time recorder for the determination of the longitude of any station. This may be done by comparing in turn the local time ascertained by star observations and

[2] The Electrician, 83: 4. July, 1919.

DEFENDANT'S EXHIBIT No. 2—Continued

the radio time signal from a known longitude with a local chronometer. It is, therefore, necessary to make simultaneous records on a chronographic drum of—

1. Local star transits against local chronometer.
2. Radio time signals against local chronometer.

From the data thus obtained the longitude of the unknown station may be computed with reference to that of the radio time signal sending station.

It is obviously desirable to have the same lag in the recording apparatus for both signals. If, therefore, both can be recorded by

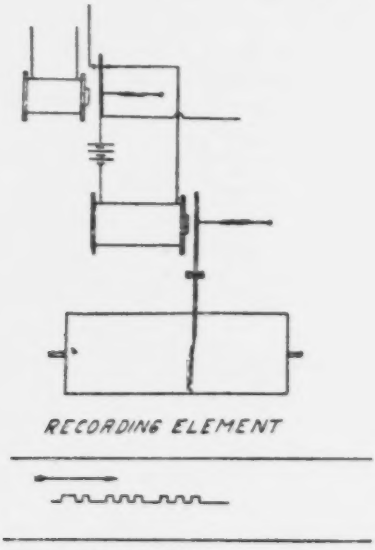


FIGURE 5.—Circuit recording element

means of the same mechanical system, i. e., with the same pen, a serious cause of difference in lag has been eliminated. How this has been accomplished is illustrated in Figure 5. The pen-operating magnet is differentially wound with two coils of approximately equal resistance and equal number of turns. The break-circuit chronometer operates a relay similar to that in the radio receiving-recording set. The clock-controlled relay energizes one of the pen magnet coils during the brief period of the clock break. If the pen is in the released position during the clock break the pen magnet is momentarily magnetized and the pen is momentarily moved

DEFENDANT'S EXHIBIT No. 2—Continued

against the inner stop. If the pen is in the attracted position the clock break will serve to demagnetize the pen magnet momentarily and the pen will be released against the outer stop during the break. The pen will record the clock break, therefore, no matter what its status with reference to the radio signal.

When star transits are to be recorded simultaneously with a local chronometer, the pen magnet winding previously utilized for the recording of the radio signals may be included in a local signaling circuit. The tapping of the signal key then operates in a manner similar to the starting of a radio signal.

Oscillographic study of the performance of a regenerative circuit with a telegraph relay with double contact in the plate arm and with the screening coil for stopping the regeneration, has shown that the oscillations are started and stopped well within 0.001 second. Figure 5 shows clearly that on the one hand we have a chain consisting of antenna—relay—pen circuit—pen, and on the other, chronometer—relay—pen circuit—pen. The two relays are similar and their reaction times are less than 0.001 second. Their difference will be considerably smaller than this amount. The pen circuits are also similar, and finally the pen is identical.

It is seen clearly that the system has been designed to minimize the lag difference of the two kinds of signals. Since comparisons of two different kinds of signals are to be made, it is only the consistency and magnitude of the lag difference which is of importance. Measurements of this quantity are to be made in a number of receiving-recording sets prior to their use in the field. The U. S. Coast and Geodetic Survey proposes to obtain an additional check by occupying a station of precisely known longitude and working the problem backwards. Thus the lag will be subjected to independent measurement in the laboratory and in the field. It is confidently expected that by the use of this recorder a new order of precision will be attained in measurements of the kind in which this apparatus may be employed.

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DEFENDANT'S EXHIBIT No. 2—Continued

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ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

DEFENDANT'S EXHIBIT No. 3

LICENSE

Whereas we, Percival D. Lowell, of Jamaica, Long Island, in the county of Queens and State of New York, and Francis W. Dunmore, of Washington, in the District of Columbia, have invented certain new and useful improvements in radio receiving apparatus for which we have obtained letters patent of the United States identified by No. 1,455,141, issued May 15, 1923, and

Whereas the Government of the United States is desirous of acquiring an interest in and to said invention:

Now, therefore, to all whom it may concern, be it known that for and in consideration of the sum of one dollar to us each in hand paid by the Government of the United States, we, the said Percival D. Lowell and Francis W. Dunmore, do hereby and herewith grant and give to the United States Government and all departments thereof represented for the purpose hereof by the Secretary of Commerce a nonexclusive, personal, irrevocable, nontransferable, and unlimited license to make and use and have made for its use devices embodying said invention anywhere and at any time the Government may see fit and to sell devices embodying said invention as provided by law regarding the sale of surplus or condemned public property, the foreign rights and all other United States rights being expressly reserved.

DEFENDANT'S EXHIBIT No. 3—Continued

The said Percival D. Lowell and Francis W. Dunmore hereby agree to make, execute, and deliver unto the Government of the United States, or to the Secretary of Commerce, any and all papers, documents, affidavits, statements, or other instruments that may be necessary in the maintaining of said letters patent and that they will aid the Government of the United States in every way in protecting their invention as may be requested.

In testimony whereof we have set our hands and affixed our seals this 2nd and 4th day of May, 1925.

PERCIVAL D. LOWELL.
FRANCIS W. DUNMORE.

COUNTY OF QUEENS,
State of New York, ss:

On this 4th day of May, 1925, before me personally appeared Percival D. Lowell, to me known and known by me to be the individual named in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same.

Witness my hand and notarial seal.

[SEAL.] HENRY M. MAHLSTEDT,
Notary Public,
Queens County No. 4225.

CITY OF WASHINGTON,
District of Columbia, ss:

On this 2nd day of May, 1925, before me personally appeared Francis W. Dunmore, to me known and known by me to be the individual named in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same.

Witness my hand and notarial seal.

CHRISTIE H. FESLER,
Notary Public, D. C.

Accepted for the benefit of the Government of the United States.

_____, _____,
Secretary.

DEFENDANT'S EXHIBIT No. 7

DECEMBER 13, 1921.

MR. F. W. DUNMORE,
Associate Physicist,
Bureau of Standards, Washington, D. C.

DEAR SIR: The matter of the disclosure in regard to a relay recorder for remote control by radio was taken up at a conference between Major Young and Mr. Press of this section and Dr. Louis Cohen of the Signal Corps. The sense of the conference was that the patent application should be proceeded with, since the "current theory" of the Carpenter reference was declared to be insufficient to warrant the suggestion of very large capacity values which you found essential for best performance. It was also the feeling of the conference that a "potential theory" practically as outlined by Mr. Press fitted the facts more exactly.

The reason for this is as follows (see diagram facing this page):

Both in the ordinary power circuit and the relay circuit it should be remembered that current i can only flow in one direction and not both, due to the rectifying nature of the valves employed. If, then, the condenser c is charged during the half wave in conformity with the current direction of i, the discharge of the condenser must take place through the inductances and not through the valves in a direction opposite to the charging direction.

It is, therefore, manifestly wrong, and wholly misleading in the matter of design, to assume that the condensers have a suitable value to by-pass the alternating current component with only a D. C. component passing through the inductances.

Comment relative to the above is requested.

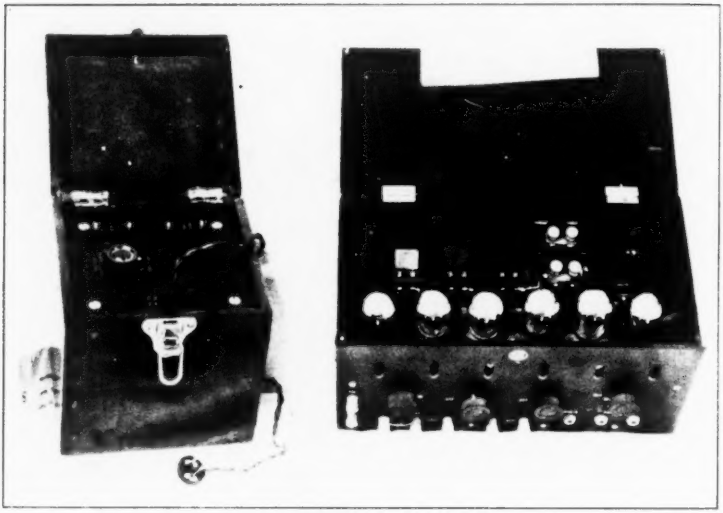
Very respectfully,

ERNEST E. HARMON,
1st Lieut., A. S.,
Acting Chief, Patents Sec.

Relay
T₂ filament
AC

Defendant's Exhibit No. 4

LOWELL & DUNMORE RADIO INSTRUMENT COMPANY SET.



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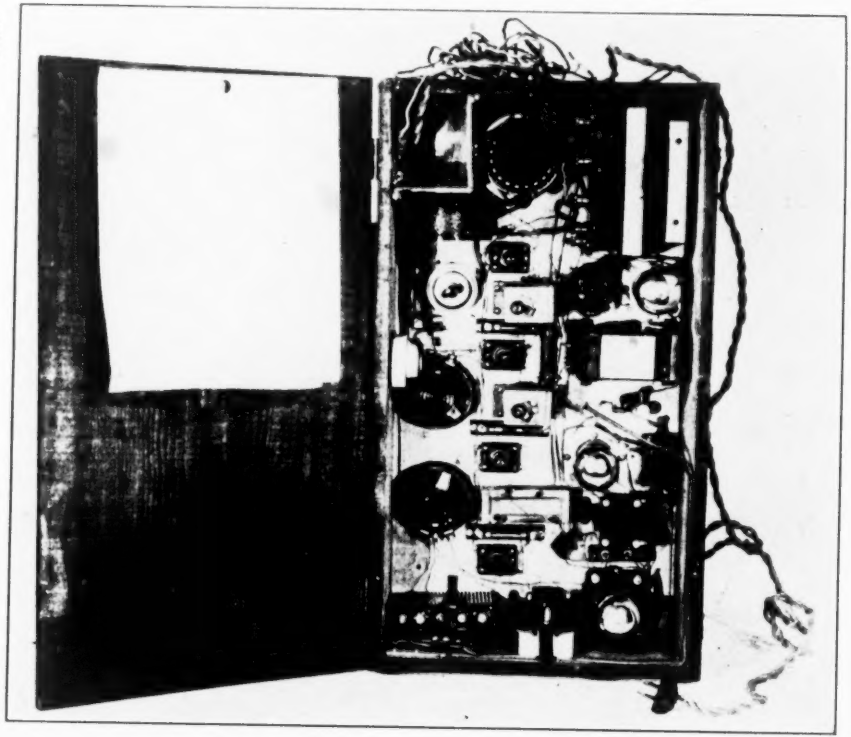
DEFENDANT'S EXHIBIT No. 5

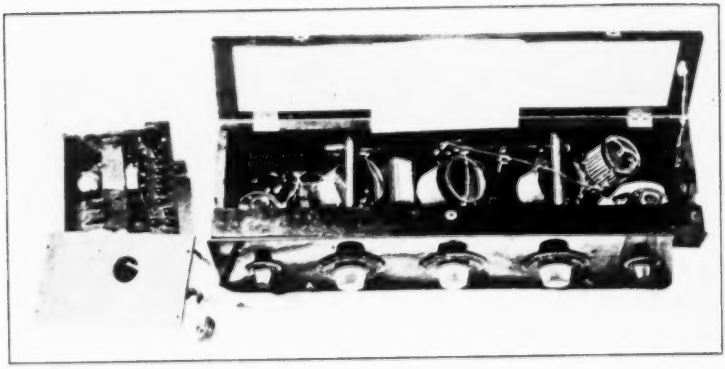
LOWELL & DUNMORE N-TUBE POWER OPERATED SET.

E-163



DEFENDANT'S EXHIBIT NO. 6

LOWELL & DUNMORE NEUTRODYNE SET.



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DEFENDANT'S EXHIBIT No. 7—Continued

FWD: AN (Subject to revision)

RADIO LABORATORY,
BUREAU OF STANDARDS,
November 30, 1921.

A RELAY RECORDER FOR REMOTE CONTROL BY RADIO

By F. W. Dunmore, associate physicist

I. Object of development.

The object of this investigation was to develop a relay which should operate by received radio signals.

II. Requirements.

To be satisfactory as a relay recorder the device should have the following characteristics: (1) It must be of simple construction with few adjustments; (2) it must be easy to adjust and capable of being put into operation quickly; (3) it must be selective and as free from static and such disturbances as possible; (4) it must be capable of operating at a speed of at least 12 times per second; (5) it must respond to weak signals; (6) it must be of rugged design, durable, and capable of maintaining its adjustments; (7) it must be portable.

III. Circuit used.

In order to avoid the use of a very sensitive relay designed to operate on currents of a milliampere or less, with delicate adjustments and light contacts and spring tension, advantage was taken of the radioaudio amplifier (which has now become a reliable radio instrument) to increase the input voltage to the relay circuit, thus making possible the use of a simple ordinary high-resistance telegraph relay. The relay device has therefore been developed to operate from the output circuit of any suitable amplifier in place of the ordinary telephone receivers. The only adjustment necessary is that of an ordinary telegraph relay.

Fig. 1 shows the wiring diagram. A is a telephone plug for connecting the relay device to the amplifier output. B is a phone socket, so that if desired the operator may listen to the received signal in the ordinary way. C is an audio transformer of the type used in audio amplifiers, the type used at present being a Signal Corps type C–21. E is a 2-megohm grid leak. Q is a 0.0006 microfarad variable condenser or 0.0003 microfarad fixed condenser. D is a 60-volt variable "C" battery variable in steps of approximately 3 volts. J is a 160-volt dry "B" battery self-contained within the

DEFENDANT'S EXHIBIT No. 7—Continued

set. K is a type UV–201 Radiotron. F and H are each a one-microfarad paper condenser. T is an ordinary telegraph relay rewound with 12,000 turns of number 38 SSC enamel wire. A′ is the output to be connected to the apparatus to be controlled. L is a step-down transformer for operating the tube filaments from the 110-volt AC supply when such a supply is available.

IV. Principle of operation.

The principle of operation is illustrated in fig. 2. By means of the variable "C" battery D, the grid voltage is adjusted to approximately 30 volts at which value the plate current is zero, as shown at A. The incoming audio-frequency voltage impressed on the grid varies the grid potential, for example, from −30 to −20 volts. The 10 volts decrease from −30 to −20 causes an increase, for example, from 0 to 10 milliamperes, while the increase from −30 to −40 volts is not effective in causing a plate current to flow due to the fact that −30 volts is already sufficient to reduce the plate current to zero. The result will be a pulsating direct current of 10 milliamperes, maximum amplitude, in the plate circuit. This current, flowing through the plate circuit and condenser F causes an increase in the plate current at the keying frequency which change, passing through the relay coil will pull the relay armature over, making contact at T, which contact may control any mechanism desired. With the "C" battery grid voltage adjusted for maximum sensitivity it was found that static, induction, etc., operated the relay. When these disturbances are not as strong as the signal their effect on the relay may be overcome as shown in fig. 3. For example, the "C" battery is shown increased to −35 volts, the critical value for maximum sensitivity being −30 volts. The disturbance due to strays, etc., merely reduce the "C" battery voltage to −30 which is not sufficient to cause plate current to flow. However, the signal, being of greater intensity than the strays reduces the voltage to −25 which causes a plate current of 5 milliamperes. It will be seen, therefore, that all disturbing effects, if of less intensity than the signal, do not effect the relay.

V. Method of increasing sensitivity and selectivity.

During the development of this relay it was found that the rectified audio-frequency current in the plate circuit caused the relay armature to vibrate rapidly in the closed position, thus causing a poor contact. This was overcome completely, however, by the addition of a one-microfarad condenser across the relay coils. This served the purpose of an audio-frequency by-path for the highly inductive winding of the relay, thus greatly decreasing the resistance

DEFENDANT'S EXHIBIT No. 7—Continued

of the circuit. The change of plate current due to this audio-frequency caused a second change which occurred at the keying frequency. This latter change passes readily through the relay coils and exerts a strong steady pull on the relay armature without the least chattering.

It was also found that the 0.0006 microfarad variable condenser, fig. 1, across the secondary of the input audio transformer made possible audio tuning, which increased the selectivity considerable. This tuning was very sharp, and it was found that European stations could be made to operate the relay while a high-power station here in the United States would fail to operate it, although the high-power station was coming in on the same wave length and slightly stronger. This was made possible by adjusting the heterodyne note of the European station to a frequency different from that of the local station and then tuning the secondary of the audio transformer to that frequency. The 0.0006 variable condenser may be replaced by a 0.0003 fixed condenser and the audio tuning accomplished by adjusting the heterodyne note to the resonant frequency. By means of this audio tuning one of three stations transmitting simultaneously have been selected and caused to operate the relay although all were of equal intensity.

VI. Speed of operation.

Tests showed that with a signal strength sufficient to produce a plate current of 10 milliamperes the relay could be operated at a speed of 48 contacts per second, the contact being sufficient to operate a buzzer. With 3 milliamperes in the plate circuit a speed of 27 contacts per second was obtained. With 1 milliampere a speed of 19 per second. In each case the relay armature spring tension was adjusted for the best operation.

VII. Sensitivity.

As stated above, this relay was designed primarily with the intention of obtaining a device which should be durable, simple in operation, and rugged in construction. Sensitivity is obtained by means of radio-audio amplification, thereby increasing the voltage input to the relay circuit and eliminating the necessity of extreme sensitivity in the relay. Tests at 600 cycles showed that the relay circuit was fairly sensitive, as approximately 1.3 volts at the input terminals of the audio transformer in the relay circuit caused a current of 5 milliamperes to flow through the relay coil in the plate circuit.

VIII. Durability.

As the relay instrument used in this recorder is of the ordinary telegraph type, its durability is well established. The only elements

DEFENDANT'S EXHIBIT No. 7—Continued

requiring occasional renewal are the two electron tubes, the 60-volt "C" battery, and the 160-volt "B" battery.

IX. Portability.

The complete recorder with the exception of the filament lighting battery is contained in a cabinet 7″x13″x11″, as shown in Fig. 4.

X. Uses.

1. As an ordinary receiver it has advantages over reception with telephone receivers, for one may receive by buzzer or sounder with all induction and interfering noises eliminated (if not louder than the signal.)

2. A tape or drum type recorder may be used and a copy made without a trained radio operator.

3. Time signals may be recorded.

4. A call system may be worked by a time switch connected to close the filament circuit for a given time at set calling intervals.

5. Any form of mechanism may be operated by an incoming signal.

6. A receiving station may be located remotely from the transmitting station and the radio signals relayed by wire to the operating room some miles distant.

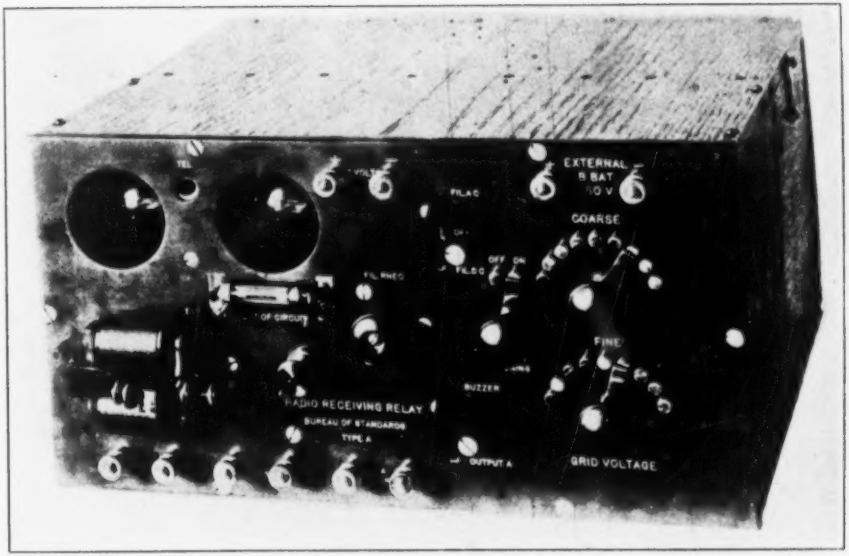
In conclusion it may be stated that a relay of this type should operate satisfactorily, without attention, on an airplane where mechanical vibration may be excessive as the pull on the armature with 3 milliamperes or over, in the relay coil makes possible the use of a spring tension on the relay armature sufficient to keep it from moving due to mechanical vibration of the relay.

It would seem that the above-mentioned feature makes this remote control relay more serviceable than those now on the market which require delicate adjustment of spring tension, contact points, and suspended vibrating elements.

Attached tracings: Radio Nos. 784–A, B, C.

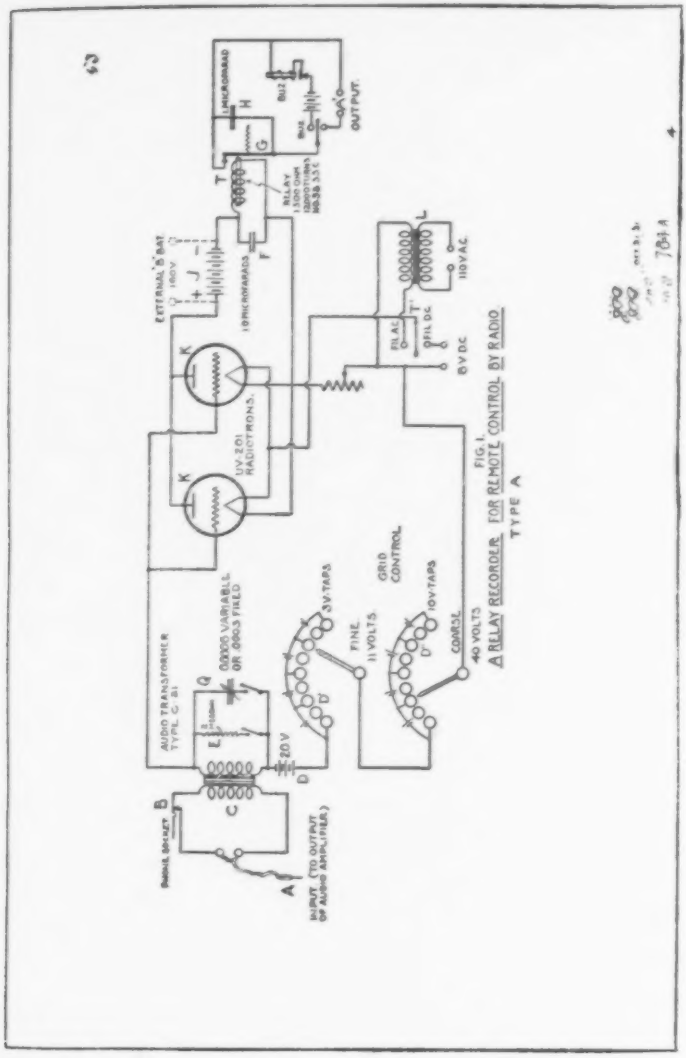
Attached photograph: Negative No. 2773.

WASHINGTON, D. C.

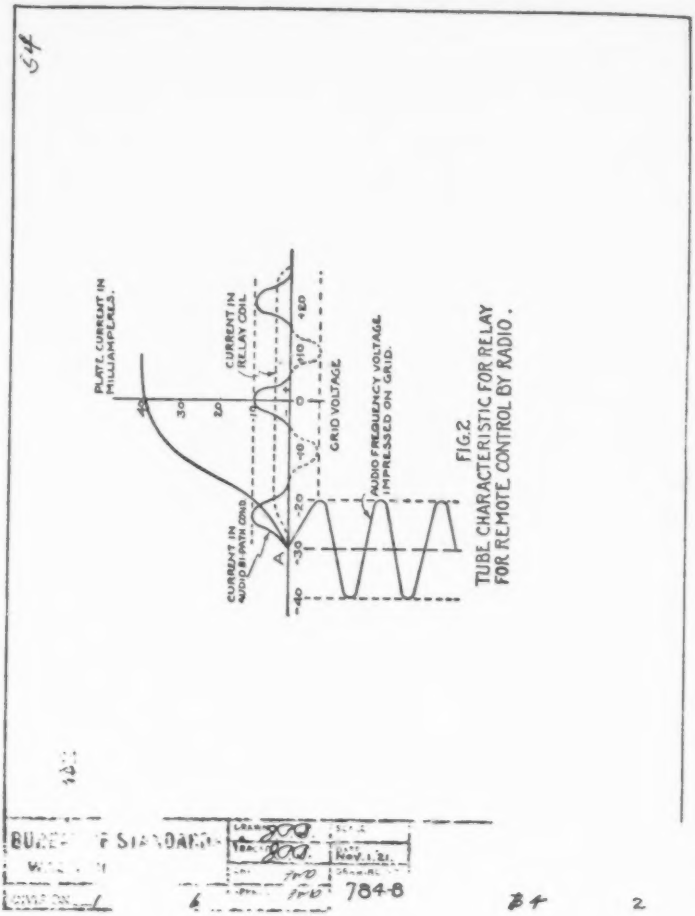


Negative No. 2773

DEFENDANT'S EXHIBIT No. 7—Continued



DEFENDANT'S EXHIBIT No. 7—Continued



DEFENDANT'S EXHIBIT No. 7—Continued

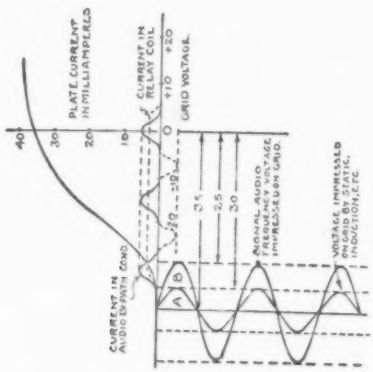


FIG. 3.

TUBE CHARACTERISTIC FOR RELAY FOR REMOTE CONTROL BY RADIO.

METHOD OF ELIMINATING STATIC INDUCTION ETC. WHICH IS NOT STRONGER THAN THE SIGNAL, BY PROPER ADJUSTMENT OF GRID VOLTAGE.

784-C

DEFENDANT'S EXHIBIT No. 8

FWD:MH
I-6

DEPARTMENT OF COMMERCE,
BUREAU OF STANDARDS,
Washington, December 15, 1921.

Lieut. ERNEST E. HARMON,
Acting Chief, Patents Section,
Air Service, War Department, Washington, D. C.

DEAR SIR: I have received your letter of December 13, 1921, and have given it careful attention.

During a telephone conversation this morning with Major Young it was suggested that a publication of the report on the recorder in question would serve to give sufficient protection to the Government without the necessity of going into patent technique. As this received Major Young's approval, I believe I shall pursue this course.

Thanking you again for your cooperation, I am,

Very truly yours,

(Sgd.) F. W. DUNMORE,
Associate Physicist.

DEFENDANT'S EXHIBIT No. 9

PROBATIONARY APPOINTMENT

DEPARTMENT OF COMMERCE AND LABOR,
APPOINTMENT DIVISION,
Washington, January 29, 1913.

Mr. PERCIVAL D. LOWELL
(Through the Director, Bureau of Standards).

SIR: You have been appointed, subject to taking the oath of office, laboratory apprentice in the Bureau of Standards, at a salary of four hundred and eighty dollars per annum, effective on the date on which you enter upon duty in the above-mentioned position.

(By selection from certificate No. 4360, and subject to a probationary period of not to exceed six months, as provided by paragraph (c) of section 1 of civil-service Rule VII, to be found on the reverse hereof.)

By direction of the Secretary.

Respectfully,

(Signed) GEO. W. LEADLEY,
Chief of Appointment Division.

Appropriation: Salaries, Bureau of Standards.
Vice: E. C. Patrick.
Legal residence, District of Columbia.

DEFENDANT'S EXHIBIT No. 9—Continued

DEPARTMENT OF COMMERCE AND LABOR

OATH OF OFFICE

I, Percival D. Lowell, do solemnly affirm that I will support and defend the Constitution of the United States against all enemies, foreign and domestic; that I will bear true faith and allegiance to the same; that I take this obligation freely, without any mental reservation or purpose of evasion; and that I will well and faithfully discharge the duties of the office on which I am about to enter: So help me God.

PERCIVAL D. LOWELL.

Sworn to and subscribed before me this 4 day of February, A. D. 1913.

H. D. HUBBARD,
Notary Public.

The above-named appointee entered upon duty on Feb. 4, 1913. Bureau or office to which assigned: "Standards (Lab. Appr. $480)."

The subsequent oaths of office and appointment and promotion certificates are in form similar to the foregoing. There follows in lieu of a reprint of each of the certificates a summary showing the date of appointment, the position to which appointed, the salary, and the appropriation to which this is charged.

Date	Position	Salary	Appropriation to which charged
Oct. 29, 1913	Laboratory apprentice	$540	Salaries, Bureau of Standards.
April 8, 1915	Aid	600	"
July 1, 1916	"	720	"
Dec. 6, 1916	Laboratory assistant	900	Salaries.
July 27, 1917	Laboratory assistant	1,000	Radio research, Bureau of Standards.
March 1, 1918	Laboratory assistant	1,200	"
Nov. 26, 1918	Laboratory assistant	1,320	"
August 16, 1919	Assistant physicist	1,500	"
July 1, 1920	Assistant physicist	1,800	Radio research.
Oct. [illegible], 1920	Associate physicist	1,980	Industrial research, war radio.
Resignation effective July 15, 1922.			

DEFENDANT'S EXHIBIT No. 10

Dec. 12 - 17, 1921. Lawrence E. Whittemore.
Cf Terrill, with Cy. P. re broadcasting + misc. matters.
Visited P.O. station and inspected R.C. of A.
radiotelephone transmitting set. (Mr. Howard)
Dict: notes on "Radio Research Field":
Cf FWD + Major Young re patent on relay
Cf Wheeler and Gilbert of Bu. Mkts. re western
trip. Cf Terrell re same.
Worked with GAP on report of broadcasting conference.
Call from Howell and Edgerton of P.O.

Comments on Godfrey's report on tel. rec. meas. in tel. rec.

Cf L.C.F. Horle re Simon interference report, + rec.
set work.
Cf MSS re slides for Chicago talk before Elec. Assn. Elkhart.
Report on present status of Air Service radio projects
dictated. On western trip beginning Dec. 16

DEFENDANT'S EXHIBIT No. 11

Dec. 12 to 17 1921 J. H. Dellinger
L & Program New outline

Sick leave, Dec 13 to 17

DEFENDANT'S EXHIBIT No. 12

Dec. 19 to 24 to 31 1921 J H Dellinger
On leave Dec 20 to 31

Memo to ECC re funds
Cf Horle on Swing job & on extension of S cales
to parts of curve, remote from max, as
a means of controlling interference
Corresp. Expanded, ATRH, line radio Inc response
started action on d.f. specs. controversy

Defendant's Exhibits under Rule 46 A to EEE

(Made physical exhibits by stipulation)

DEFENDANT'S EXHIBIT No. 13

REPORT OF THE DIRECTOR, BUREAU OF STANDARDS

Report made physical exhibit by stipulation except the following portions:

DEPARTMENT OF COMMERCE,
BUREAU OF STANDARDS,
Washington, July 1, 1921.

SIR: There is submitted herewith a report of the work of the Bureau of Standards for the fiscal year ended June 30, 1921.

I. FUNCTIONS, ORGANIZATION, AND LOCATION

Before describing in detail the various scientific and technical problems in which the Bureau of Standards is engaged the following brief statement as to its functions and organization may be helpful to those unfamiliar with the subject of standardization in its broad and modern sense.

The standards with which the bureau is authorized to deal may be conveniently classed as follows: Standards of measurement, standard values of constants, standards of quality, standards of mechanical performance, and standards of practice.

1. Definition of standards

STANDARDS OF MEASUREMENT.

A standard of length may be taken as an example of a standard of measurement. It must be a length which is unchanging, reproducible, and capable of being compared with the working standards used in the most precise scientific work or with those used in commerce and industry. In order to carry out such comparisons, working standards must be prepared which are subdivisions and multiples of the fundamental standard, and this process of subdividing and multiplying the standard involves difficulties as great as those met with in the preparation of the fundamental standard itself.

The construction of a set of standard weights from a single unit is also an illustration; a whole set of standard weights must be prepared before the standard weight of the Government can become available to the public. Before these working standards, made up of subdivisions and multiples of the fundamental standard, can be prepared questions as to the methods of comparison arise, which again involve the solution of difficult scientific problems in connection with the balance or the methods used. These balances range from that capable of measuring the thousandth part of a milligram to the large testing machine capable of measuring a load of thousands of tons. The complete range must be covered, which involves not only a

DEFENDANT'S EXHIBIT No. 13—Continued

large number of working standards, all of which must agree with the fundamental standard, but apparatus suitable for the comparison of these standards with all of the lengths or weights found in practice. These steps and equipment are absolutely essential in order to secure uniform measurements of length or weight throughout the country, and they have their counterpart in every quantity that has to be measured, whether it be length, weight, temperature, heat, light, or the various electrical measurements or other standards of measurement. These standards in one form or another are involved in practically every scientific investigation, industrial process, engineering structure, or commercial transaction.

PHYSICAL CONSTANTS (STANDARD VALUES).

There are many fixed relations between physical quantities, the values of which it is extremely important to know. These values are usually termed "physical constants" and are used in every branch of scientific work or industry. The amount of heat required to change a pound of water into steam under normal conditions and the relation between heat and mechanical energy are two important physical constants. Their values are used in practically every computation in connection with the designing of steam engines and boilers, the tests of their efficiencies, or the measurement of their output. The amount of heat required to turn liquid ammonia into vapor or the amount of heat required to melt a pound of ice are constants equally important in the refrigerating industries. The value of the relation between electrical and mechanical energy is involved in many commercial transactions concerned in electricity.

Accurate and authoritative values of these constants are just as essential as in the case of standards of measurement. Many of those now in use are old and obsolete and need redetermination by means of the best modern facilities for physical measurement. Their determination involves the most difficult and precise work in all branches of physics and chemistry—a fact not generally known by those not engaged in the scientific or technical work where these constants are used.

STANDARDS OF QUALITY.

A standard of quality for a given material may sometimes take the form of a sample of that material with which other materials of the same kind can be compared, but this is generally a makeshift of the poorest sort. It is only resorted to in the absence of definite and reliable specifications in terms of measurable properties; that is to say, a standard of quality of a material usually takes the form of a specification or definition of its properties, involving, of course, the measurement of those properties by means of the usual standards of

DEFENDANT'S EXHIBIT No. 13—Continued

measurement. A certain kind of steel, a cement, a paint, an oil, a paper, or a cloth is found by use to be good or poor for a definite purpose. The questions then arise: Why is it good or poor? What are the physical or chemical properties or the particular combination of elements which make it of good or poor quality? How are its properties to be measured or its constituents determined? These are questions for the laboratory to answer and involve physical and chemical investigations of the most difficult sort.

A standard of quality for a given material necessarily takes into account the purpose for which the material is to be used. To set the standard too low results in losses, poor efficiency, and even loss of life; to make it too high may result precisely in the same thing; that is to say, the material must be suitable for the purpose intended, and the bureau's investigations in connection with the properties of materials are to enable the user of these materials, first, to select intelligently the material best suited for the purpose; second, to specify it in terms which the producer can not mistake; and, third, to make the necessary tests to ascertain whether or not the material supplied is in accordance with the specifications.

The actual testing of materials by the Bureau of Standards to ascertain whether or not they comply with specifications is confined almost exclusively to Government purchases, but in making these tests (in which the bureau has had the hearty cooperation of practically all the departments of the Government service) it is compelled to make many investigations concerning the properties of materials, their specification, and measurement. While this work is of great value in placing Government purchases on a correct business basis, the results of the investigations as to the properties of materials and the information gained in testing Government supplies are even more important to the general public and are distributed in the form of suitable publications.

The bureau does not compete with private testing laboratories but endeavors to assist them by the development of standard specifications, methods of measurement, and other matters where uniformity is desirable, much of which information, as stated above, is secured in connection with the testing of materials purchased by the Government and a close observation of their use.

The time is not far distant when it will be required that all material bought and sold shall be as represented, but it should be kept in mind that this is impossible except in the case of those materials for which proper standards of quality and methods of measurement have been developed. It must not be assumed that the purchaser or user is the only party benefited in the development of such standards. On the

DEFENDANT'S EXHIBIT NO. 13—Continued

contrary, the manufacturer, first of all, is interested in all things which affect the quality of his product. The research work and tests conducted by the bureau have done a great deal in pointing out those properties upon which the quality of a material depends, and in connection with this work it is worth while to remember that not only are the important properties pointed out but the ways for measuring them are indicated. The facilities of the bureau are not extensive enough to permit it to conduct all the research work in which the manufacturers of this country would like it to engage, but the value and importance of its work along these lines is becoming more and more appreciated and is being extended each year.

STANDARDS OF PERFORMANCE.

The value of an instrument, device, or machine almost always depends upon the efficiency of its performance. In such cases it is necessary to state the performance desired or guaranteed in terms which are correct and susceptible of measurement. As in the case of standards of quality, the standard involved is more often in the form of a specification, but specifications are useless unless based upon correct scientific and mechanical principles and supplemented with a statement of the method to be used in ascertaining whether or not the specification or guaranties have been complied with.

The performance of an engine or boiler, a pump, an electrical generator or motor, a weighing device, or a telescope can usually be measured, but the quantities to be measured and the methods used must be specified correctly and understood by all the parties concerned in the construction, purchase, or use of such apparatus. To secure information upon which to base proper standards of performance involves investigations quite as scientific in character and as difficult as in the case of other standards, as well as a knowledge of technical and manufacturing processes. In this field, as well as in the field dealing with the properties of materials, the bureau has had the hearty cooperation of the various Government experts, manufacturers, engineers, and technical societies. It has conducted many investigations which have led to improvements in machinery, appliances, and manufacturing processes.

STANDARDS OF PRACTICE.

Standards of practice are generally involved in the enactment of laws when technical and scientific matters are concerned, in the ordinances relating to the regulation of public utilities, and in the establishment of building and safety codes. Like standards of performance, they are dependent upon standards of measurement and standards of quality and are of the most vital importance in ques-

DEFENDANT'S EXHIBIT No. 13—Continued

tions pertaining to the welfare and safety of the public. In a field so broad the bureau can only touch upon the more important aspects of the work, where national uniformity is desired—fields which are not covered in private laboratories.

2. Relation of the bureau's work to the public

COMPARISON OF STANDARDS OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS OR OF THE PUBLIC WITH THOSE OF THE BUREAU.

It is perfectly obvious even to one unfamiliar with the subject that the maintenance on the part of the Government of correct standards of measurement or quality or performance calls for continuous scientific and technical investigations of the highest grade, involving the most competent expert services and the best scientific equipment. When this is accomplished there still remains the serious problem of making the results available and useful to the public.

The bureau compares with its own standards of measurements the standards and measuring instruments of States, cities, scientific laboratories, educational institutions, or the public, for which a nominal fee is charged, except in the case of the National and State Government institutions. It is at all times glad to assist these institutions in matters concerning these standards or their use, whether it be in connection with the enactment of laws, regulations, or ordinances concerning the weights and measures of everyday trade or in connection with precision standards used in scientific work.

V. GENERAL RECOMMENDATIONS

SALARIES.

I must again call attention to a serious condition which has been mentioned in the last three reports of this bureau, but unfortunately without effect, namely, the great disparity between the salaries paid scientific and technical experts in the Government service and men engaged in similar work for industrial concerns and educational institutions. This is a real menace to the research work of the Government, which in time will be felt by every industry and individual throughout the country.

While, as mentioned in the introductory chapter of this report, the bureau can offer a reasonably good entrance salary to young men just out of college, it can not compete on anything like equal terms with outside organizations when the more responsible positions are considered. The men in these positions are among the most valuable in the Government's employ, and many have voluntarily remained in the service from a sense of patriotic duty and at large financial

DEFENDANT'S EXHIBIT No. 13—Continued

sacrifices. On the other hand, a large number have been forced to accept positions with private corporations, schools, and colleges, although in doing so they realize that the opportunities for research will be far less than in a national institution.

There should be no need for such sacrifices as those just mentioned. The Government can afford to pay and should pay its experts a salary on a plane with that which they can earn in private employment. This matter is particularly serious in the case of the Bureau of Standards, as its sole product is scientific information, which is dependent entirely upon scientific research of the highest grade. Many of the investigations necessarily cover long periods, and the loss of the expert in charge may be equivalent to setting back the whole investigation for a year. It is earnestly recommended that steps be taken immediately to remedy this situation, the seriousness of which is becoming greater each year.

POWER PLANT.

As pointed out in the reports for 1919 and 1920, the power plant of the Bureau of Standards has for several years been inadequate to meet the demands made upon it. The original plant was well adapted to take care of the requirements of the bureau at the time it was built, but the institution has now completely outgrown the equipment. It has been necessary to install two additional boiler plants to furnish sufficient steam for heating purposes, and the greater part of the electrical service for power and light is now bought from the local power company. Such decentralization is wasteful and unsatisfactory. It is a well known fact that a number of small units are far less economical than a larger central plant. Commercial electric power is poorly adapted to supply exacting laboratory requirements. Interruptions to such service can not be avoided, and such cessations of the power supply may mean the loss of valuable experimental data through the shutting down of laboratory equipment.

A modern central power plant capable of supplying all the necessities of the bureau in the way of heat, light, power, refrigeration, compressed air, and vacuum services should be constructed as soon as possible. The first cost of such a plant would be saved in a short time through greater economy in power production and more satisfactory service.

CARE OF BUILDINGS.

The number of janitors, laborers, and watchmen necessary to properly care for the buildings and grounds is still entirely inadequate. As stated in the previous report, laboratories require considerably more janitor and watchman service than ordinary build-

DEFENDANT'S EXHIBIT No. 13—Continued

ings. The nature of the work is such that it requires constant care to keep the buildings in order. Many experiments require continuous operation of some sort, and in buildings where such work is in progress watchmen must be constantly on the alert. The watchmen must use intelligence in case of accident and give attention to continuous operations. To curtail necessary services of this character is questionable economy, and it is a well known fact that lack of such service has resulted in accidents, thefts, and poor upkeep of buildings.

BUILDINGS AND GROUNDS.

It is recommended that provision be made by Congress for the purchase of the land between the present boundary of the bureau's property and Connecticut Avenue on the east. This tract is needed to round out the site, and as it will without doubt be purchased eventually it would be better to secure it now before it is built upon.

Although some progress has been made during the year in grading and clearing up the grounds and in the construction of short stretches of permanent road a more adequate fund should be provided for this purpose.

Respectfully,

S. W. STRATTON, *Director.*

To Hon. HERBERT HOOVER,
Secretary of Commerce.

DEFENDANT'S EXHIBIT No. 14

[Report made physical exhibit by stipulation except the following portions:]

REPORT OF THE DIRECTOR, BUREAU OF STANDARDS

DEPARTMENT OF COMMERCE,
BUREAU OF STANDARDS,
Washington, July 1, 1922.

SIR: There is submitted herewith a report of the work of the Bureau of Standards for the fiscal year ended June 30, 1922.

I. FUNCTIONS, ORGANIZATION, AND LOCATION

Before describing in detail the various scientific and technical problems in which the Bureau of Standards is engaged the following brief statement as to its functions and organization may be

DEFENDANT'S EXHIBIT No. 14—Continued

helpful to those unfamiliar with the subject of standardization in its broad and modern sense.

The standards with which the bureau is authorized to deal may be conveniently classed as follows: Standards of measurement, standard values of constants, standards of quality, standards of mechanical performance, and standards of practice.

Definition of standards

STANDARDS OF MEASUREMENT.

A standard of length may be taken as an example of a standard of measurement. It must be a length which is unchanging, reproducible, and capable of being compared with the working standards used in the most precise scientific work or with those used in commerce and industry. In order to carry out such comparisons, working standards must be prepared which are subdivisions and multiples of the fundamental standard, and this process of subdividing and multiplying the standard involves difficulties as great as those met with in the preparation of the fundamental standard itself.

The construction of a set of standard weights from a single unit is also an illustration; a whole set of standard weights must be prepared before the standard weight of the Government can become available to the public. Before these working standards, made up of subdivisions and multiples of the fundamental standard can be prepared, questions as to the methods of comparison arise, which again involve the solution of difficult scientific problems in connection with the balance or the methods used. These balances range from that capable of measuring the thousandth part of a milligram to the large testing machine with a capacity of thousands of tons. The complete range must be covered, which involves not only a large number of working standards, all of which must agree with the fundamental standard, but apparatus suitable for the comparison of these standards with all of the lengths or weights found in practice. These steps and equipment are absolutely essential in order to secure uniform measurements of length or weight throughout the country, and they have their counterpart in every quantity that has to be measured, whether it be length, weight, temperature, heat, light, or the various electrical measurements or other standards of measurement. These standards in one form or another are involved in practically every scientific investigation, industrial process, engineering structure, or commercial transaction.

PHYSICAL CONSTANTS (STANDARD VALUES).

There are many fixed relations between physical quantities, the values of which it is extremely important to know. These values are

DEFENDANT'S EXHIBIT No. 14—Continued

usually termed "physical constants" and are used in every branch of scientific work or industry. The amount of heat required to change a pound of water into steam under normal conditions and the relation between heat and mechanical energy are two important physical constants. Their values are used in practically every computation in connection with the designing of steam engines and boilers, the tests of their efficiencies, or the measurement of their output. The amount of heat required to turn liquid ammonia into vapor or the amount of heat required to melt a pound of ice are constants equally important in the refrigerating industries. The value of the relation between electrical and mechanical energy is involved in many commercial transactions concerned in electricity.

Accurate and authoritative values of these constants are just as essential as in the case of standards of measurement. Many of those now in use are old and obsolete and need redetermination by means of the best modern facilities for physical measurement. Their determination involves the most difficult and precise work in all branches of physics and chemistry—a fact not generally known by those not engaged in the scientific or technical work where these constants are used.

STANDARDS OF QUALITY.

A standard of quality for a given material may sometimes take the form of a sample of that material with which other materials of the same kind can be compared, but this is generally a makeshift of the poorest sort. It is only resorted to in the absence of definite and reliable specifications in terms of measurable properties; that is to say, a standard of quality of a material usually takes the form of a specification or definition of its properties, involving, of course, the measurement of those properties by means of the usual standards of measurement. A certain kind of steel, a cement, a paint, an oil, a paper, or a cloth is found by use to be good or poor for a definite purpose. The questions then arise: Why is it good or poor? What are the physical or chemical properties or the particular combination of elements which make it of good or poor quality? How are its properties to be measured or its constituents determined? These are questions for the laboratory to answer, and involve physical and chemical investigations of the most difficult sort.

A standard of quality for a given material necessarily takes into account the purpose for which the material is to be used. To set the standard too low results in losses, poor efficiency, and even loss of life; to make it too high may result precisely in the same thing; that is to say, the material must be suitable for the purpose intended, and the bureau's investigations in connection with the prop-

DEFENDANT'S EXHIBIT NO. 14—Continued

erties of materials are to enable the user of these materials, first, to select intelligently the material best suited for the purpose; second, to specify it in terms which the producer can not mistake; and, third, to make the necessary tests to ascertain whether or not the material supplied is in accordance with the specifications.

STANDARDS OF PERFORMANCE.

The value of an instrument, device, or machine almost always depends upon the efficiency of its performance. In such cases it is necessary to state the performance desired or guaranteed in terms which are correct and susceptible of measurement. As in the case of standards of quality, the standard involved is more often in the form of a specification, but specifications are useless unless based upon correct scientific and mechanical principles and supplemented with a statement of the method to be used in ascertaining whether or not the specification or guaranties have been complied with.

The performance of an engine or boiler, a pump, an electrical generator or motor, a weighing device, or a telescope can usually be measured, but the quantities to be measured and the methods used must be specified correctly and understood by all the parties concerned in the construction, purchase, or use of such apparatus. To secure information upon which to base proper standards of performance involves investigations quite as scientific in character and as difficult as in the case of other standards, as well as a knowledge of technical and manufacturing processes. In this field, as well as in the field dealing with the properties of materials, the bureau has had the hearty cooperation of the various Government experts, manufacturers, engineers, and technical societies. It has conducted many investigations which have led to improvements in machinery, appliances, and manufacturing processes.

STANDARDS OF PRACTICE.

Standards of practice are generally involved in the enactment of laws when technical and scientific matters are concerned, in the ordinances relating to the regulation of public utilities, and in the establishment of building and safety codes. Like standards of performance, they are dependent upon standards of measurement and standards of quality and are of the most vital importance in questions pertaining to the welfare and safety of the public. In a field so broad the bureau can only touch upon the more important aspects of the work, where national uniformity is desired—fields which are not covered in private laboratories.

DEFENDANT'S EXHIBIT No. 14—Continued

Relation of the bureau's work to the public

Comparison of standards of scientific and educational institutions or of the public with those of the bureau.

It is perfectly obvious, even to one unfamiliar with the subject, that the maintenance on the part of the Government of correct standards of measurement or quality or performance calls for continuous scientific and technical investigations of the highest grade, involving the most competent expert services and the best scientific equipment. When this is accomplished there still remains the serious problem of making the results available and useful to the public.

The bureau compares with its own standards of measurement the standards and measuring instruments of States, cities, scientific laboratories, educational institutions, or the public, for which a nominal fee is charged, except in the case of the National and State Government institutions. It is at all times glad to assist these institutions in matters concerning these standards or their use, whether it be in connection with the enactment of laws, regulations, or ordinances concerning the weights and measures of everyday trade or in connection with precision standards used in scientific work.

V. GENERAL RECOMMENDATIONS

SALARIES.

The question of salaries of the scientific employees in the Government service has been so much before the public of late that it might be considered unnecessary to refer to it again. However, this problem is of such extreme importance in the case of the Bureau of Standards and is so closely connected with its satisfactory functioning that I feel compelled once more to call attention to the very unsatisfactory conditions which exist.

At the time my last annual report was prepared, most of the industries in this country were passing through a period of extreme depression. At such times the salaries which can be offered by private corporations are naturally far less attractive than during periods of commercial activity. Nevertheless, the bureau lost many members of its scientific staff, who felt obliged to accept the higher pay which they could obtain in private employ, although by so doing they realized that they were lessening their opportunities for research work. As a matter of fact, it is this devotion to their work which has enabled the bureau to keep its staff in a reasonably efficient condition; without this loyalty the labor turnover in the more important positions would be excessive.

DEFENDANT'S EXHIBIT NO. 14—Continued

During the coming fiscal year, with industrial conditions improving everywhere, Government scientific institutions will be under a greater handicap than ever before, and it will become increasingly difficult to render efficient service. The staff of a scientific laboratory can not be picked up "overnight" to carry a peak load. New employees in scientific positions, no matter how willing they may be, are an actual drag on the work of the more experienced members of the staff until they become familiar with the particular problems in hand. The loss of one man from a laboratory may set back an entire investigation much more effectively than the destruction of all that laboratory's equipment.

There should be no need for such financial sacrifice on the part of scientific men in the Government service. We can and ought to pay them salaries commensurate with the importance of the work and more nearly on a plane with what they can earn in the industries and in educational institutions.

It is, therefore, again earnestly recommended that steps be taken to remedy this situation. Such action will be found in the end to be a paying investment for the entire country.

POWER PLANT.

The need of a new power plant for the Bureau of Standards has been pointed out in previous annual reports. Entirely aside from the more reliable service which would be rendered by a plant specially designed to meet the needs of a research institution, the matter is of particular importance at the present time owing to the greatly increased economy which would result from centralization of the bureau's heating and power-producing equipment. The tendency in all lines of work is toward centralization of equipment, and it is well known that nowhere does this result in greater economy than in the operation of a power plant.

The bureau's original plant, designed for two buildings, and now supplemented by two separate boiler plants for heating purposes and numerous pieces of electrical equipment for changing the electric power bought from the commercial company into energy suitable for the needs of the laboratories, forms a glaring example of decentralization with the unavoidable accompaniment of high labor charges and low fuel economy. Owing to the small capacity of the electric generating equipment of the bureau's plant, it has been found necessary for some years to purchase a large part of the current from the local power company. Such a source of supply is necessarily much less reliable than a plant specially designed for the needs of a research institution.

DEFENDANT'S EXHIBIT No. 14—Continued

It is believed that the expenditure necessary to build a modern central power plant capable of caring for all the probable future needs of the bureau would be saved in a short time through increased economy in fuel and operation and greater reliability in the service rendered.

CARE OF BUILDINGS.

The same conditions as regards the number of janitors, laborers, and watchmen necessary to properly care for the buildings and grounds, as mentioned in my report of last year, still apply. The bureau is made up of a large number of separate buildings, each of which contains a great deal of valuable apparatus and in which some processes must necessarily be carried on day and night. Watchmen with more than ordinary intelligence are therefore absolutely necessary. To curtail services of this character is questionable economy, and may result in accident and loss of equipment. The force at present provided is too small and should be increased immediately.

BUILDINGS AND GROUNDS.

It is again recommended that provision be made by Congress for the purchase of the land between the present boundary of the bureau's property and Connecticut Avenue on the east. This tract is needed to round out the site, and as it will without doubt be purchased eventually it would be better to secure it now before it is built upon.

Considerable progress has been made in grading and clearing up the grounds and in the construction of some permanent road, but a more adequate fund is needed to properly finish up this work and to keep the bureau's grounds in proper condition.

Respectfully,

S. W. STRATTON,
Director.

To Hon. HERBERT HOOVER,
Secretary of Commerce.

Defendant's Exhibits, under Rule 46, Nos. A to EEE made physical exhibits by stipulation.

U. S. GOVERNMENT PRINTING OFFICE: 1931

461 In United States Circuit Court of Appeals for the Third Circuit

No. 4656 (List No. 103). October term, 1931

UNITED STATES, APPELLANT

vs.

DUBILIER CONDENSER CORP., APPELLEE

Order assigning judge filed Dec. 10, 1931

Appeal from the District Court of the United States for the District of Delaware.

And now, to wit, this tenth day of December, A. D. 1931, it is ordered that Hon. Albert W. Johnson, district judge for the middle district of Pennsylvania, be, and he is hereby, assigned to sit in above case in order to make a full court.

VICTOR B. WOOLLEY,
Circuit Judge.

[File endorsement omitted.]

462 In United States Circuit Court of Appeals for the Third Circuit

[Title omitted.]

Minute entry of argument and submission

And afterwards, to wit, the 10th day of December, 1931, come the parties aforesaid by their counsel aforesaid, and this case being called for argument sur pleadings and briefs, before the Honorable Victor B. Woolley and Honorable J. Warren Davis, circuit judges, and Honorable Albert W. Johnson, district judge, and the court not being fully advised in the premises, takes further time for the consideration thereof,

And afterwards, to wit, on the 24th day of May, 1932, come the parties aforesaid by their counsel aforesaid, and the court, now being fully advised in the premises, renders the following decision:

463 In United States Circuit Court of Appeals for the Third Circuit

Nos. 4656, 4657, 4658. October Term, 1931

UNITED STATES OF AMERICA, PLAINTIFF-APPELLANT

v.

DUBILIER CONDENSER CORPORATION, DEFENDANT-APPELLEE

Appeals from the District Court of the United States for the District of Delaware

OPINION

Filed May 24, 1932

Before Woolley and Davis, Circuit Judges, and Johnson, District Judge.

Woolley, Circuit Judge.

The Bureau of Standards is a subdivision of the Department of Commerce and is maintained by the United States for scientific and engineering research. Although originally organized for the purpose of testing and maintaining standards of measurements and solving cognate problems in the interest of the general public, there has been delegated to it from time to time by acts of the Congress additional duties of making scientific research in specific fields.

464 Various departments of the Government are authorized to transfer funds to the Bureau of Standards for the purpose of carrying on scientific investigations in which they are particularly interested, as also does the bureau carry on research in various projects of special interest to private industries, sometimes without cost and other times at their expense. Among its enlarged powers is that of "investigation and standardization of methods and instruments employed in radio communication." (38 Stat. 1044.) To this end it set up a "radio section." In this section Percival D. Lowell and Francis W. Dunmore were employed as laboratory assistants and associate physicists and were engaged in carrying on investigation, research, and experimentation in such problems relating to radio and wireless as might be requested by other departments of the Government and be assigned to them by their superiors.

In the course of their employment Lowell and Dunmore were members of the "airplane radio" group, to which were submitted numerous research projects for the benefit of the Air Corps. The subject of "radio receiving sets" was given to a group of which Lowell and Dunmore were not members. At the time in question these two employees were assigned to work on airplane project No. 38 for a "visual indicator for radio signals" and project No. 42 for "airship bomb control and marine torpedo control by radio." Both

projects required the design of a radio relay operated by direct current—that is, of a mechanism for use on an airplane to receive the output from a radio receiver and to relay it to a coil on the airplane—which would operate either a visual indicator or a trigger; such trigger in turn to release a bomb on a pilotless plane or a marine torpedo. In the midst of these problems Lowell and Dunmore, impelled solely by their own scientific curiosity and moving outside the scope of the particular work to which they had been
465 assigned, directed their minds to the problem of substituting house lighting alternating current for direct battery current in different branches of radio apparatus, which is discussed at length in Radio Corporation of America *v.* Dubilier Condenser Corporation, 34 Fed. (2d) 450; — Fed. (2d) —. After developing this idea, which was not related to the remote control relay devised for aircraft use, these employees appeared in the Patent Office.

Lowell and Dunmore, claiming to have invented a radio receiving apparatus whose principal characteristic was the elimination of hum, were awarded Letters Patent No. 1,455,141; Dunmore, claiming to have invented a signal-receiving system, was awarded Letters Patent No. 1,635,117; and, again, both together, claiming to have invented a power amplifier, were awarded Letters Patent No. 1,606,212.

The patentees assigned these letters patent to the Dubilier Condenser Corporation. The Government, realizing, of course, that, by force of the act of June 25, 1910 (Chapter 423, 36 Stat. L. 851), amended by act of July 1, 1918 (Chapter 114, 40 Stat. L. 705), it had limited licenses under these patents in the nature of shoprights to use the apparatus and system invented by the patentees during their employment, but conceiving that it had the higher rights of full ownership in the inventions and title to letters patent, asserted them by these three suits instituted on bills of complaint which are alike except in their references to the different letters patent, praying in each instance that it be decreed the full owner of the invention and that the defendant be directed to assign to it all its rights, title, and interest in the letters patent. The Government averred as the basis of its property rights that in the course of their employment there were assigned to Lowell and Dunmore for investigation and research the problems of developing a radio receiving set, a
466 signal-receiving system, and a power amplifier capable of operation by house lighting alternating current so that the use of electric batteries in such apparatus might be eliminated. (These are the precise subjects matter of the patents.) Pursuant to these instructions they, in the performance of their duties, proceeded to carry on studies, research, investigation, and experimentation in those problems, and did work at the radio laboratory of the Bureau of Standards with apparatus and material which were the property of the United States, during their usual hours of employment, which resulted in the inventions and letters patent in question.

When the cases came on for hearing before the district court, the Government, first adhering to, and introducing evidence to prove, the straight averments of its bills that Lowell and Dunmore were in each instance specifically assigned to work out the respective scientific problems and that, in consequence, their inventive achievements belonged to it, their employer, somewhat stepped aside from its former stand in the bills and took a position, outside the bills, that failing proof of assignment to the respective tasks the results of the labors of Lowell and Dunmore "in the general field of (their) work" were equally its property and, therefore, called for a decree for a formal assignment of the patents. The District Court, holding against the Government on both its theories, entered decrees dismissing the bills. 49 Fed. (2d) 306. The Government appealed. We shall dispose of the three appeals in one opinion.

The Government on these appeals takes the same alternative positions it took in the court below on its claimed right of property in the inventions of its employees, as affected by their assignment or lack of assignment to particular problems out of which grew the inventions, and formulates and stresses as its main contention this question:

467 "Whether the title to patents granted on inventions made by technical research employees of the Bureau of Standards, at the Government laboratories, principally during the regular hours of employment, with the use of Government-owned material, and with the assistance of Government mechanics and draftsmen, the inventions relating to matters comprised within the general field of the patentees' work, although the specific problem had not been thought of or included in the assignment of duties, is vested in the United States as employer of the inventors."

This statement of the main question, if involving any uncertainty of meaning, is made clear by the Government's later statement that:

"It does not matter whether Lowell and Dunmore were specifically assigned to do the work which resulted in the inventions in suit. Admittedly the work was within the general field of their employment, for their duties were to do research and development work in radio."

In arguing this question the Government admits on the threshold that it was the employer of the inventors and that its property rights in their inventions were those of an employer. Accordingly, it approaches, step by step, the broad right claimed in its main question through the law of the subject arising out of the relation of employer and employee, varied by circumstances.

Its several propositions are these:

(1) "Inventions made by employees outside of office hours, without the use of material belonging to the employer and having no bearing upon the employee's duties," are the property of the employee, in which the employer has no interest.

This is so obviously sound that it does not require the sup-
468 port of authorities.

(2) "Inventions arising out of or made in connection with the employee's duties, and incidental thereto, by an employee whose duties do not include the carrying on of research or inventive work" (and, we would add, in the absence of a contract therefor), are the property of the employee in which, however, the employer has a shopright or a nonexclusive license to use the invention.

This, too, is sound; but, because of the narrow line that sometimes appears in such cases in respect to the employee's employment and duties, we cite as supporting authorities Hapgood v. Hewitt, 119 U. S. 226; Dalzell v. Dueber Watch Case Mfg. Co., 149 U. S. 315; Pressed Steel Car Co. v. Hanson, 137 Fed. 403; Ingle v. Landis Tool Co., 272 Fed. 464; Amdyco Corp. v. Urquhart, 39 Fed. (2d) 943; 51 Fed. (2d) 1072; Moffett v. Fiske, 51 Fed. (2d) 868.

(3) "Inventions made by an employee in connection with his work and within the scope of his work, whose duties include the carrying on of research or inventive work," become the sole property of the employer, together with the accompanying patents.

It will be observed that this proposition is the last step toward the proposition of law embodied in the Government's main question involved. It approaches that question so closely, indeed it so impinges upon it, that it is impossible to give it unqualified approval. The juxtaposition of the words "research" and "inventive work" throws the statement out of balance. If the proposition were reformed and made to read, that inventions of an employee, specifically employed or assigned to make them, are the sole property of the employer, we should approve it on authority of Solomons v. United States, 137 U. S. 342; Gill v. United States, 160 U. S. 426; Standard
Parts Co. v. Peck, 264 U. S. 52; United States v. Houghton,
469 23 Fed. (2d) 386; Magnetic Mfg. Co. v. Dings Magnetic Separator Co., 16 Fed. (2d) 739.

So, following the Government's ascending steps of admitted law and doubtful law as to property in invention between employee and employer, we reach the point where the Government lays down and asks the court to pronounce an entirely novel principle of law arising out of that relation, to the effect that where an employee is a member of its research bureau, with the duty to make research on whatever subject assigned, yet when he makes an invention wholly outside the task to which he has been assigned, it becomes the property of the Government employer because made "in the general field of the (employee's) work." This proposition of law can be sustained only by giving the word "research" the meaning of the word "invention," or by ignoring or reversing the law of the authorities we have cited. The Government, however, relies for the law under its third proposition and its main question involved upon four or five cases, also cited by the appellee. If these cases do not support its claim of property

in inventions arising out of work for which the inventors were not employed or to which they were not assigned, it has no support in authority, nor indeed has it support in reason unless we should regard a general employment for research work as synonymous with particular employment (or assignment) for inventive work, and should extend to the Government, because of its superior quality as an employer and the superior character of its work, a right of property in its employees' inventions higher than that which the law extends to other employers similarly situated.

The first case on which the Government relies is Solomons v. United States, 137 U. S. 342. That was a suit not by the United States asserting title to a patent but by the patentee, assignee of the inventor, to recover from the Government for use of the
470 invention. Clark, Chief of the Bureau of Engraving and Printing and therefore an employee of the Government, contrary to the fact admitted in the Government's main question in the instant case, had been specifically assigned to the task out of which the invention emerged and the letters patent was granted. While it was later said in Gill v. United States, 160 U. S. 426, 435, that on that fact the Government, in a proper proceeding, could have asserted title to the invention, for, in making the invention, Clark was merely doing what he was hired to do, the decision in that case was, on the same fact, merely to the effect that the patentee could not recover from the Government.

Gill v. United States, 160 U. S. 426, was a suit by a patentee to recover a royalty or other compensation from the Government for use of his invention on a showing that the patentee, an employee of the Government, required to exercise mechanical skill but not employed or assigned to exercise inventive genius, devised an improved method of doing his work, using the property and labor of his employer to put his invention into practical form and later assenting to its use by the employer. The court held that he could not recover from the Government, saying, however (quoting from Solomons v. United States), that in such case the property remains in the patentee and the Government, though entitled to a shopright or limited license, has no more power to appropriate his property vested in a patent than it has to take his property vested in real estate.

Standard Parts Company v. Peck, 264 U. S. 52, was a suit for infringement. On a finding that the patentee had been employed expressly to develop a process and machinery for manufacturing a specified product and that in developing the invention in the
471 course of his work he did nothing more than what he was hired and paid to do, the court held the invention belonged to the employer.

Houghton v. United States, 23 Fed. (2d) 386, is the last case we shall discuss. There Houghton, a research chemist in the employ of the Public Health Service of the Treasury Department, was as-

signed to the particular problem of developing a certain kind of gas in collaboration with employees of the Chemical Warfare Service in accordance with their advice and along the lines indicated by previous study and investigation. This was a specific assignment to specific work. The result was successful. Houghton, who contributed to the success, claiming that it was invention and that he was the inventor, applied for and obtained a patent. The United States brought suit, claiming that as employer it was the equitable owner of the invention and demanding an assignment of the patent. The court, distinguishing the cases we have cited in their application to different situations, held that property in the invention resided in the United States, with the right to an assignment of the patent not because of the patentee's general employment as a research chemist in its bureau and not because the invention was made by the research employee "within the general field of (his) work" but because of his express assignment to the specific work of which the invention was a result.

Summarizing these decisions, it appears that in each of the three cases—Solomons v. United States, Standard Parts Co. v. Peck, and Houghton v. United States—the situation was that an employee, afterwards the patentee, had been specifically assigned by his employer to the problem resulting in the invention. In the fourth case—Gill v. United States—there was no assignment to the problem and the Government made no claim to the invention.

472 It is equally clear that all these decisions for the Government were based on the law applicable to a private employer. Indeed, the Supreme Court said in Solomons v. United States, approved in Gill v. United States: "There is no difference between the Government and any other employer in this respect." Nor has the Government called to our attention any cases involving kindred questions that have been decided upon any other theory. Thus we have gone to some pains to show that the Government's claim of property in the inventions in suit is based on its relation as employer to its employees and on its assertion of a higher right to their "inventions within the general field" of their research work without regard to the facts that ordinarily control the cases of private employers. This position of the Government, we discern from the drift of the argument, is really based on the factual assumption that all research work in the bureau is primarily concerned with invention and is so closely related to it as to be practically a part of it. We find nothing in the record or in the common meaning of the two words to suggest this identity. Failing that, we are back to general law which forbids us laying down a new principle that, if invention occurs in the general field of an employee's occupation, the employer would, without regard to the facts that control the law in varying situations, be entitled to receive the fruits of the employee's invention.

We hold against the Government on its statement of the first question involved.

The Government, recognizing the possibility of an adverse decision on the question of law as stated in its first or main question involved, presents in the alternative a question of fact, as follows:

"Whether, on all the facts, the patented inventions covered
473 matters which were specifically assigned to the patentees for research and development by their superior at the Bureau of Standards."

We have carefully studied the record in this case, first, with the assistance of the very thorough briefs and, again, independently of the briefs. We do not think it necessary to reproduce our work in this opinion by a lengthy recital and discussion of the evidence. It will be enough to say that, in accord with the learned trial judge, we find no evidence that would sustain a finding that Lowell and Dunmore were assigned by their superior to any research or development problems involving the inventions in controversy. Having given particular attention to dates, about which these questions revolve, we think the most that the evidence shows is that Lowell and Dunmore, after completing their inventions in substance, called them to the attention of their superior, who being greatly interested permitted and encouraged them to pursue their work in the laboratory and perfect the inventions in detail. All this amounted to conduct after the event and is, therefore, not controlling.

The decrees are affirmed.

A true copy.

Teste:

(Clerk of the United States Circuit Court of Appeals for the Third Circuit.)

474 In United States Circuit Court of Appeals for the Third Circuit

No. 4656. October Term, 1931

UNITED STATES, APPELLANT
vs.
DUBILIER CONDENSER CORP., APPELLEE

Decree filed May 24, 1932

Appeal from the District Court of the United States for the District of Delaware.

This cause came on to be heard on the transcript of record from the District Court of the United States for the District of Delaware, and was argued by counsel.

On consideration whereof it is now here ordered, adjudged, and decreed by this court that the decree of the said district court in this cause be, and the same is hereby, affirmed.

Philadelphia, May 24, 1932.

VICTOR B. WOOLLEY,
Circuit Judge.

[File endorsement omitted.]

475 [Clerk's Certificate to foregoing transcript omitted in printing.]

476 Supreme Court of the United States

No. 316. October Term, 1932

Order allowing certiorari. Filed October 17, 1932.

The petition herein for a writ of certiorari to the United States Circuit Court of Appeals for the Third Circuit is granted. And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

477 Supreme Court of the United States

No. 317, October Term, 1932

Order allowing certiorari. Filed October 17, 1932.

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